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AUTHOR Upitis, Rena
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ABSTRACT

This study assesses 7- to 12-year-old children's abilities to understand the figural and metrical aspects of rhythm. Tasks were developed to assess children's ability to (1) make figural and metrical descriptions, (2) interpret figural and metrical descriptions, (3) produce the metrical hierarchy through drumming, (4) describe the metrical hierarchy, and (5) relate the metrical hierarchy to the surface durations of a melody. Tasks were presented individually through a standardized clinical interview to 72 children in second through seventh grades. Nonparametric statistics were used to test for significant differences across age groups and between musically trained and untrained subjects; protocol analyses were related to quantitative findings. Results indicated that the differences between musically trained and untrained children in terms of metrical understanding are not as strong as would have been expected from prior research. Additionally, it was found that all children were able to understand both figural and metrical forms to differing degrees; musically trained children did not lose their figural understanding in the process of developing their metrical abilities. Findings are discussed in terms of music education practices. Suggestions for highlighting the figural aspects of rhythm are given, and ways of moving to metrical descriptions are discussed. It is argued that teachers and students should learn to integrate the figural and metrical forms at all levels of musical training and performance. (Author/RH)

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CHILDREN'S UNDERSTANDING OF RHYTHM: THE RELATIONSHIP BETWEEN DEVELOPMENT AND MUSICAL TRAINING

Rena Upitis

Harvard University
Cambridge, Massachusetts

Queen's University
Kingston, Ontario

PS 014631

Presented at the Music in Early Childhood Conference, June 28-30, 1984, Provo, Utah.

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ABSTRACT

This study assesses seven- to twelve-year-old children's abilities to understand the figural and metric aspects of rhythm. Tasks were developed to assess children's ability to (1) make figural and metric descriptions, (2) interpret figural and metric descriptions, (3) produce the metric hierarchy through drumming, (4) describe the metric hierarchy, and (5) relate the metric hierarchy to the surface durations of a melody. Tasks were presented individually through a standardized clinical interview (N=72). Children were asked to respond in several domains (motoric, verbal, symbolic).

Drawings of simple rhythms and the metric hierarchy were classified by type and level of representation. The ability to keep time was assessed by rating children on their ability to find different beats for several melodies.

Non-parametric statistics were used to test for significant differences across age groups and between musically trained and untrained subjects. Protocol analyses were related to the quantitative findings. One of the surprising results is that the differences between musically trained and untrained children in terms of metric understanding are not as strong as would have been expected from prior research. The most important finding is that all children are able to understand both figural and metric forms to differing degrees. Also, musically trained children do not lose their figural understanding in the process of developing their metric abilities.

The findings are discussed in terms of music education practices. Suggestions for highlighting the figural aspects of rhythm are given. Ways of moving to metric descriptions are discussed. It is argued that it is important that both teachers and students learn to integrate the figural and metric forms at all levels of musical training and performance, reflecting the figural and metric organizational forms present in the music itself.

CHILDREN'S UNDERSTANDING OF RHYTHM: THE RELATIONSHIP BETWEEN DEVELOPMENT AND MUSICAL TRAINING

Rhythm notation is typically one of the most difficult aspects of music to teach. However, even a cursory examination of children's abilities to reproduce simple rhythms and to keep time to melodies indicates that children have powerful rhythm understanding. One is therefore led to ask: Why is rhythm notation difficult to teach if children bring a solid form of rhythm knowledge to the learning situation?

The first step in looking for reasons for why rhythm notation is hard for children to learn is to consider closely the nature of musical rhythm. In doing so, it is vital that one bears in mind that rhythmic organization in music depends not only on the structure inherent in the notated aspects of the music, but also on the contribution of the listener or performer - what he or she does in organizing the relationships among the various sounds into a coherent whole.

Two types of rhythmic organization both in music and in terms of an individual's means of understanding music have been identified: **figural** and **metric** grouping. When listening to a piece of music, the listener naturally organizes the sounds into meaningful groups or units. One type of figure is the melodic figure, a small, structurally meaningful segment or chunk of the melody. Larger meaningful groups may also be formed, such as phrases, themes, sections and the piece itself (Lerdahl & Jackendoff, 1983). Frequently figural boundaries are generated by a change in duration of adjacent notes, so that proximate elements are perceived as belonging together and separated from the other elements not perceived as belonging in the figure. The relationship among the notes in a figure is not only durational, but also functional, based on the way in which each element functions in the figure (e.g., the last note in a figure has a different

function than a note in the middle of a figure, even if they are of the same duration). In music notation, figures are sometimes depicted by slurs or phrase marks, which are added to the notation denoting pitch and duration. People who respond to the figural aspect of rhythmic structure focus on the ways in which the elements of the melody form clusters or groups, relating to the functional aspects of the elements rather than responding consistently to the duration of each element.

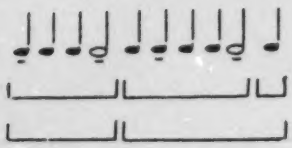
The listener also infers another kind of rhythmic organization from the music he hears. Even though the surface durations of a melody are likely to vary, listeners are capable of inferring underlying regular patterns of strong and weak beats. The metric hierarchy is manifested in people's ability to tap along at different rates in response to the varied surface durations of a melody. These invariant underlying patterns of beats form the basis of hierarchic metric rhythmic organization.

Each of the levels of the metric hierarchy can be measured in terms of the other levels and in terms of the varied surface durations of the melody. The underlying metric hierarchy is the the form of rhythm organization encoded by standard music notation. The metric system provides a way of comparing and classifying all of the events in the sequence according to a consistent durational system, based on a fixed reference unit. Thus, all of the notes are notated so that the duration of a note can be compared to the duration of any other note in relative terms, regardless of the function of any of the notes in figural groups.

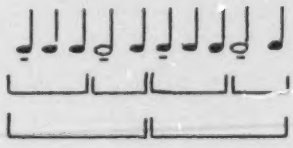
One powerful way of demonstrating people's internal representations of the two forms of organization, metric and figural, is by examining graphic and numeric descriptions of depict simple rhythms (see Figure 1). Most adults and children describe rhythms in a manner that is either distinctly

Figure 1. Figural and Metric Drawings of a Simple Rhythm

Music Notation

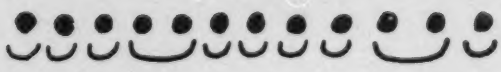


Figural Groups



Metric Groups

Figural Drawing



Metric Drawing

figural or metric (Bamberger, 1980, 1982), even though they might respond to the other mode of rhythmic organization in their behaviour. For example, a child might graphically represent a rhythm figurally, but nevertheless be able to keep time to music, a response based on the metric form of rhythm organization.

A figural description reflects the listener's attempt to depict the sequence according to the perceived clusters or groups of events in the sequence. Any single event is depicted only in relation to the other events within the immediate figure. In contrast, metric drawings represent the listener's attempt to compare or measure the durations of each of the notes in the sequence with all of the other notes, according to a formal or standardized system. Thus, the metric form of description highlights the same aspect of rhythm organization as standard music notation. Metric descriptions, however, often obscure figural groups. On the other hand, while figural drawings highlight the perceived relationships between adjacent notes, figures are context bound. Therefore, a symbol used for one event in a figure cannot be consistently compared, in terms of duration, to the same symbol for another event, since the choice of symbol is dependent both on duration and the function of the event in the particular figure.

Rationale

One plausible reason for the difficulty in teaching rhythm notation stems from a mismatch of children's internal representations of rhythm and the standard music notation form used for teaching rhythm notation. Although children appear to be able to respond 'naturally' on some level, to both the figural and metric aspects of the rhythmic structure, the notation form which they can understand most readily is to figural form.

However, many music teachers emphasize the metric (formal) mode of notation since this is the form of standard music notation. In order to teach rhythm more effectively, a teacher should have some understanding of the children's existing knowledge of rhythmic structure. In addition, a teacher should have information about how children's abilities change over time, with and without musical training, in order to make use of their existing rhythm understanding (e.g., figural) to move to new forms of understanding (e.g., how the figural and metric modes interrelate). This study focusses on the development of seven- to twelve-year-old children's abilities to represent metric and figural aspects of rhythm. These abilities are related to musical training and general cognitive development.

Review of the Literature

Research on rhythmic organization in music has typically focussed on the physical aspects of the music stimuli (e.g., Fraisse, 1964, 1981, 1982) or rhythmic "sensitivity" or ability (e.g., Bentley, 1966; Shuter, 1968; Wing, 1948). Only recently have researchers begun investigating the cognitive processes used by listeners and performers in organizing musical sequences into rhythmic structures (Bamberger, 1980, 1982; Smith, 1983). While the research stimulus characteristics and perception has been useful in setting the scene, there is now a need to turn to the listener's mind to better understand rhythm cognition. As Minsky (1981) notes, "we must enlarge our aspirations to see that music theory isn't only about music, but about how people process it...Music...should make more sense once seen through the listener's minds".

Studies of rhythm cognition, particularly on the development of rhythm cognition, are scarce. Significant pioneering work on rhythm

cognition was carried out by Pflederer (1964), in that she introduced a Piagetian outlook to rhythm research. However, the most promising model for rhythm processing is based on the description of the interaction between figural and metric grouping phenomena in terms of the music itself and in terms of the cognitive capabilities of the listener/performer (Lerdahl & Jackendoff, 1981, 1983; Bamberger, 1980; Smith, 1983). This model is explored here in relation to rhythm development.

Prior research indicates that all children can respond to some aspect of both figural and metric organization in simple non-pitch rhythms and unaccompanied melodies (Bamberger, 1980, 1982; Upitis, 1983). It is predicted that almost all children will be able to keep time to the melodies at different rates, with increasing accuracy as they grow older (Petzold, 1963; Upitis, 1983). The ability to keep time indicates that children have metric "knowledge-in-action" (Bamberger and Schon, 1980) of rhythmic structure.

As Gardner (1971) and Smith (1983) observe, one of the shortcomings of virtually all psychological models of rhythm development is their failure to consider individual differences. The recent work of Smith (1983) and Bamberger (1980, 1982) sheds light on the effects of individual differences in musical training on the ability to process rhythmic sequences figurally or metrically. Smith and Bamberger have researched people's ability to reproduce and represent sequences of various durations. In addition to considering training differences, this study considers age-related developmental differences as they interact with musical training. Tasks have also been designed to specifically study children's knowledge of the metric hierarchy.

Gardner (1971) has observed that another aspect of rhythm development

is the changing use of domains employed by children to "make sense" of rhythm. Accordingly, the experimental tasks used here give children the opportunity to respond motorically and symbolically, using numbers and graphic symbols. The variety of tasks and media also reflects the view that learning involves the development of multiple descriptions, rather than improving or changing on a single unidirectional measure (Bamberger, 1982), and further, that the building of new knowledge is based on an broad existing knowledge base (Piaget, 1981; Boden, 1980; Brown, 1975, 1979; Goodman, 1980; Minsky, 1981).

The Research Questions and Expected Results

Four research questions are proposed. First, how does a child's ability to respond in terms of the figural and metric modes of rhythm organization vary with age? Second, how are these responses affected by prior musical training? Third, to what extent can the responses be described in terms of an interaction between age and training? Finally, since the development of musical intelligence can be related to cognitive development in general, to what extent do the responses reveal something about the underlying cognitive processes involved?

Those students with prior musical training are expected to make metric descriptions, and to be unable to interpret figural descriptions. Children without musical training are expected to make and interpret figural descriptions accurately, but be unable to interpret metric descriptions. Regardless of the form of description used and understood by the children, it is hypothesized that the ability to represent rhythm will become increasingly sophisticated with age. The most advanced understanding would be exhibited by a child who is able to make, interpret, and relate both figural and metric descriptions of rhythm.

METHOD

Subjects

Seventy-two children, seven to twelve years of age, served as subjects. All of the children in grades 2 to 7 in an urban public school in a middle class district in Kingston, Ontario, were classified as musically trained or untrained. Subjects were considered to be musically trained if they had received music lessons out of school for at least one year, including note reading instruction. Children were classified as "musically untrained" if their musical background was limited to the music instruction provided through the public school music program. Six musically trained and six musically untrained subjects for each age level (7, 8, 9, 10, 11 and 12 years) were randomly selected to serve as subjects.

The Research Tasks

Two tasks were used to assess children's ability to make and to interpret figural and metric descriptions of simple rhythms using graphic and numeric forms of description. Two further tasks assessed children's ability to generate a metric hierarchy by keeping time to melodies and through numeric description. The final task assessed children's ability to describe the metric hierarchy, as related to the varied surface durations of the melodies.

The tasks were presented individually through a standardized clinical interview. The children were interviewed twice, at their school, during regular school hours. Each interview ranged from thirty to forty-five minutes in length. All of the interviews were audiotaped. The descriptions made by the children were coded by independent observers after the interviews were completed. Other responses related to the production or interpretation of rhythms and their descriptions were coded during the

clinical interview by an independent observer. The coding was checked by another observer from the audiotapes of the interviews.

The non-pitch rhythms that were used for the description tasks are shown in Figure 2. Possible figural and metric groupings for each of the sequences are given. The sequences are also described in terms of meter and motif.

The melodies used for the metric tasks (producing and describing the metric hierarchy) appear in Figure 3. All of the melodies are tonal, two are common children's tunes. The other three melodies were composed in a similar style, but do not present the possible confounding factor of familiarity with the words of the tune. The melodies include duple, triple, and compound duple meters. All melodies have long notes and/or dotted notes, and therefore at some levels of the metric hierarchy the beat is not actually contained in the surface durations. All melodies were audiotaped from a computer version, where all notes were generated with equal intensity.

Describing Simple Rhythms

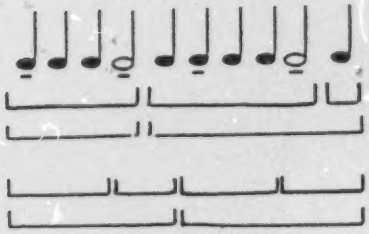
This task is a replication of the task described by Bamberger (1982). The child listens to the experimenter clap a sequence of varied durations. The experimenter stresses the first beat of each metric group. The child is then asked to clap back what he or she heard. Once the child has clapped the sequence correctly, he or she is invited to describe the rhythms by "put[ting] down on paper whatever you think will help you remember the...piece tomorrow or help someone else to play it who isn't here today" (Bamberger, 1982, p. 194). After the child has made the drawing, he or she is asked to "put in some numbers under the drawing that seem to fit with the marks you have made". If the child uses numbers

Figure 2. Non-Pitch Rhythms

Duple Repeated Motif (DR)

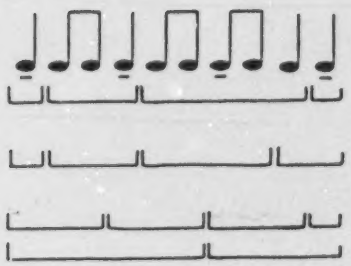
- the rhythm was clapped in duple meter, as indicated by the stress marks (-)
- the hierarchical figural groups coincide with the metric grouping

Triple Repeated Motif (TR)



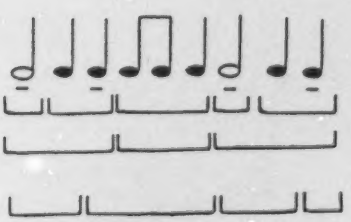
- the rhythm was clapped in triple meter, as indicated by the stress marks (-)
- the top two sets of brackets mark the figural groups
- the bottom two sets of brackets mark the metric groups

Duple Non-Repeating Motif (DN)



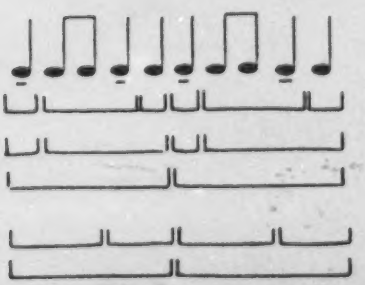
- the rhythm was clapped in duple meter, as indicated by the stress marks (-)
- the pattern is regarded as a non-repeating motif pattern, even though the quarter note followed by two eighth notes occurs twice, since this "repeating motif" is not perceived as repeating by a listener
- the top two sets of brackets mark two different possibilities for figural grouping
- the bottom two sets of brackets mark the metric groups

Triple Non-Repeating Motif (TN)



- the pattern was clapped in triple meter, as indicated by the stress marks (-)
- the top two brackets indicate the figural groups
- the bottom bracket shows the metric grouping
- the pattern is regarded as a non-repeating motif pattern, even though the half note followed by two quarter notes occurs twice since this "repeating motif" is not perceived as repeating by a listener
- this pattern is the only one with three different durations

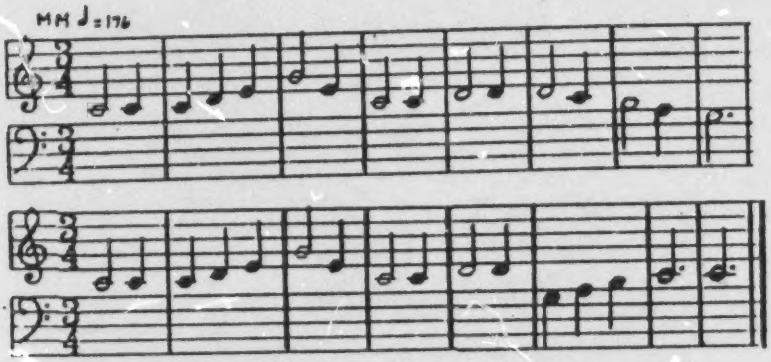
Last Duple Repeated Motif (DL)



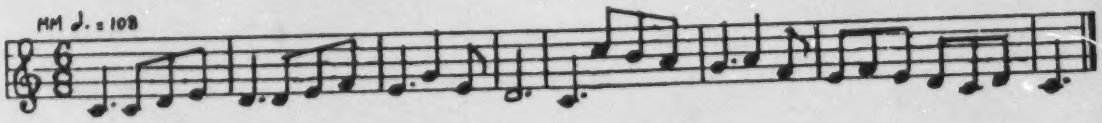
- this pattern was clapped in duple meter, as indicated by the stress marks (-)
- the top three brackets indicate the figural groups
- the bottom two brackets indicate the metric grouping

Figure 3. Melodies

Familiar Melodies



Unfamiliar Melodies



instead of graphic symbols for the first description, the child will be asked to "make some marks to go along with the numbers you have used". The same procedure was used for the first four sequences described in Figure 2.

Interpreting Descriptions of Simple Rhythms

This task involves other descriptions of the duple repeated motif rhythm, not of the child's making (figural if the child used metric and vice versa). These descriptions appear in Figure 4.

The experimenter explains a "different kind of drawing". The figural drawings were described as highlighting "groups of claps that sound like they belong together". The metric drawings were described as depicting how "long and short claps compare with each other". The child is then asked to clap from her drawing, then from the different kind of drawing. The child is also invited to clap from the other descriptions that were like her own. Finally, the child is asked to identify which drawings were the most and least helpful for "figuring out the rhythm".

The child is then given a mixed series of drawings of the duple non-repeating motif sequence, some figural and some metric (see Figure 5). The child is told that all of the drawings are of the same rhythm, a "mystery rhythm". The child is asked to try to "guess the mystery rhythm by clapping it, picking out the one that you find easiest to read". The child is then asked which drawing(s) "helped you figure out the rhythm", to see if the child used figural and/or metric drawings to interpret the sequence. The child is asked to clap the other drawings as well, and is asked to identify the "most helpful" drawing.

Following the interpretation of the drawings of the mystery rhythm, the child is asked to describe another rhythm, using the same method as for the first task. The rhythm for the final description is the last rhythm

Figure 4. Descriptions of the Duple Repeated Motif Rhythm

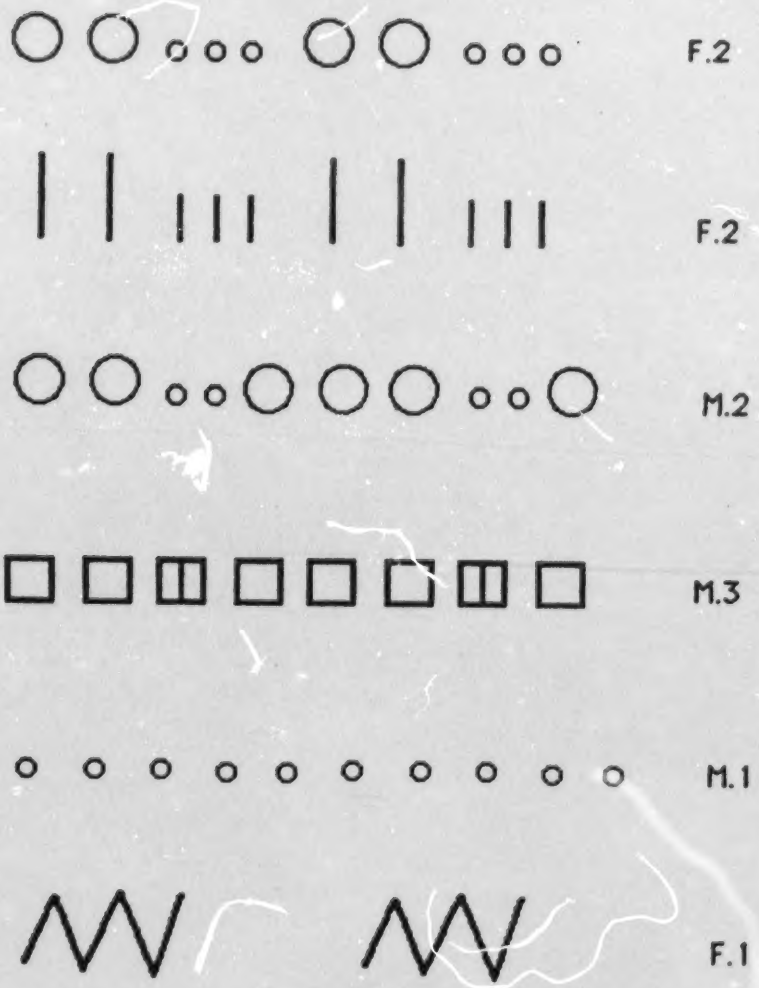


Figure 5. Descriptions of the Duple Non-Repeating Motif "Mystery" Rhythm

described in Figure 2.

Keeping Time With the Melody

The child is asked to mark time using a drum, without music: "See if you can drum a steady beat on the drum". Then the child is asked to drum a faster beat and a slower beat.

Then the child is asked to drum along with a melody played on a tape recorder. The instructions to the child are: "See if you can use this drum to keep time with the tune that you will hear. I'd like you to try to find more than one beat for each tune, like you did just now without a tune". If the child's drumming coincides with the surface events of the tune, the child is given the additional instruction: "Can you make a drum beat that could go along with more than one tune?". If the child is still unable to find a beat, she is again asked to drum a steady beat by himself without any music. Then the experimenter repeats the original instructions. If the child is still unable to keep time with the melody, the experimenter demonstrates a beat, asking the child to match the beat.

If the child is confused about the instructions for finding another different beat, she is given the additional prompt; "See if you can find a faster (slower) sounding beat". If the child is still confused, the experimenter demonstrates a different beat (although not while the melody is playing).

The same procedure is carried out with all the melodies, in the same order, for all subjects.

Identifying Congruent Beats

The melodies for this task are the first two original tonal tunes in Figure 3. An audiotape of the two melodies was used along with a metronome for generating beats. The metronome numbers were changed so that the

proportional relationships in the metric hierarchy could be more simply described.

Before recording the children's responses, the children are given an opportunity to hear the melody alone, the metronome alone at various rates, and one or two examples of congruent/incongruent beats, before being asked to specify and judge their own beats.

The experimenter asks the child to pick a beat length, choosing between the numbers two and eight for the duple melody, and three and nine for the triple melody. The child is then asked if the beat "fits" the tune. The child's response is recorded. The experimenter continues to ask the child to pick beat lengths until all of the beats for each melody have been selected. The child is asked to identify his or her favorite beat for each melody.

Drawing Beats

This task has two parts. For the first part, the child is asked to "imagine that you have gone back to your classroom and you find that an orchestra has appeared. Most of the members of the orchestra have parts, and they're playing the first tune [original duple melody]. But there are three drummers without parts, and when you come into the room, Mr./Mrs. [classroom teacher's name] asks you to write something down for the drummers. One of the drummers is going to drum a fast beat, one will drum a medium beat, and one will drum a slow beat". The above scenario is repeated for the second tune (original triple melody) with the exception that "only two drummers will drum this time". Two beats were required for the triple melody (instead of three) since the pilot study indicated that there were usually only two beats that were naturally drummed and described for the triple melody.

After the child has completed the drawings, he or she is shown "how some kids draw the drummers' parts", and is asked if she can "explain how the drawings work" (see Figure 6 for the "other drawings").

Finally, the child is asked to add a drum beat to a spatial analog version of the varied durations of one of the melodies: "This is one way of drawing of the notes of the first tune [experimenter sings tune, pointing to surface events while singing]. Can you draw in the drummers' parts with the melody part?". The instructions are repeated for the second tune. The melodies, along with coordinated drawings of the metric hierarchy, are shown in Figure 7.

Classification of Responses

Graphic and Numeric Descriptions

The graphic and numeric descriptions consisted of the descriptions of the non-pitch rhythms, the drumming, and of the metric hierarchy with the spatial analogs of the duple and triple melodies.

All of the descriptions were judged by the two independent observers. Inter-rater reliability averaged 96.97%, with a standard deviation of 2.61 (see Table 1).

Non-Pitch Rhythms

Drawings and numerical descriptions of the non-pitch rhythms were classified as iconic, figural (two types) or metric (three types). Likely graphic and numeric descriptions for each of the rhythms in Figure 8.

Iconic drawings are pictures describing the activity rather than the rhythm. For example, the child might draw a pair of clapping hands. Nothing about the original rhythm cannot be reconstructed from these drawings.

The two types of figural drawing (Early Figural: F.1, and True

Figure 6. Alternate Drumming Descriptions

Duple Melody

Triple Melody

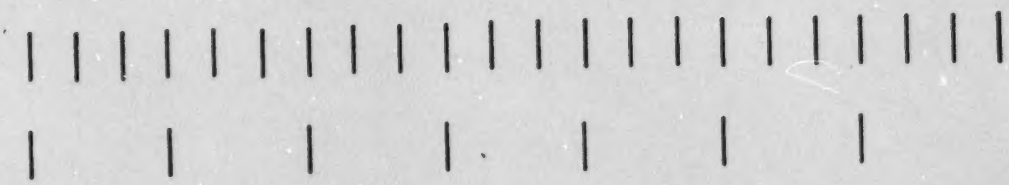


Figure 7. Spatial Analogs of Melodies with Metric Hierarchies

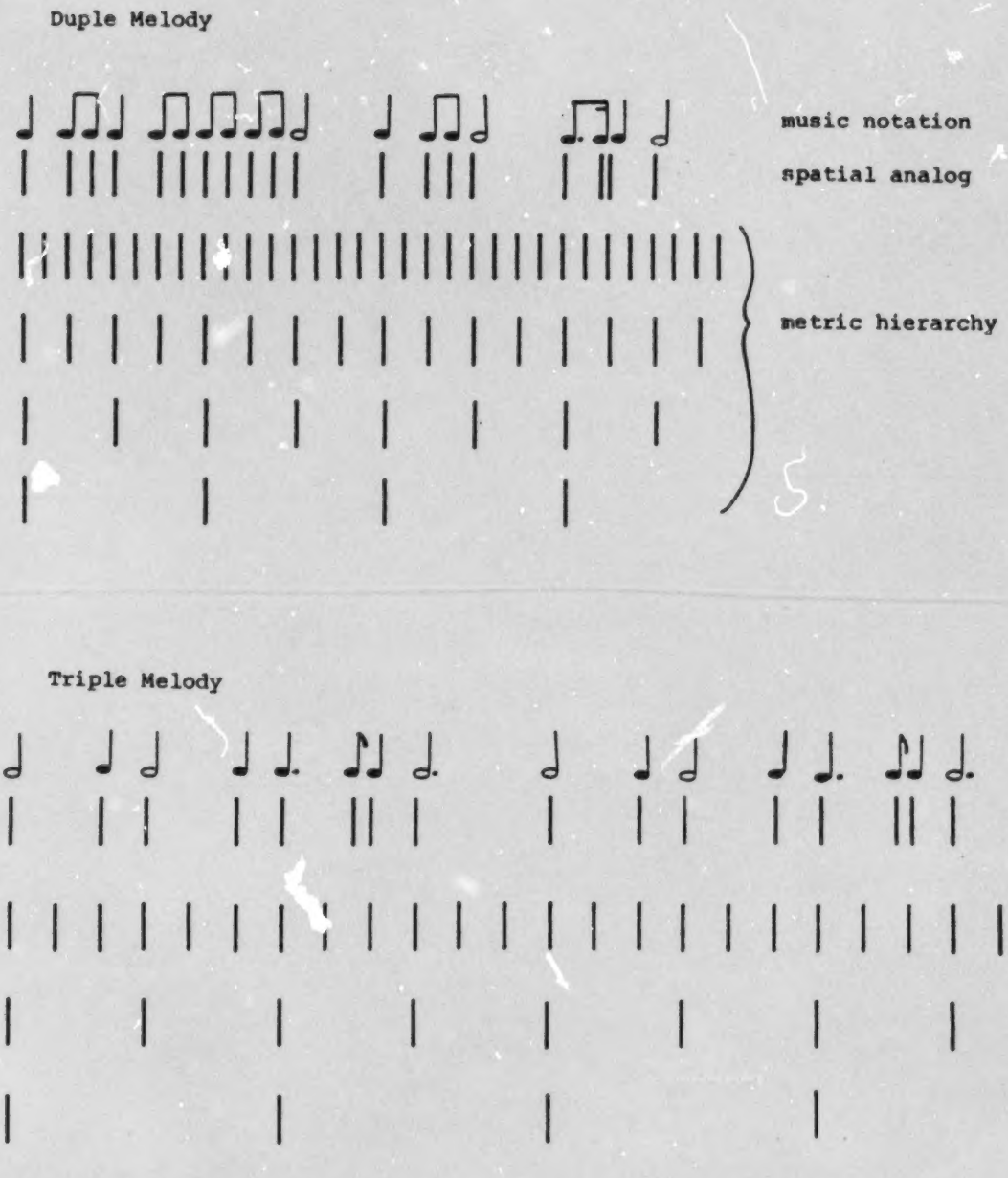


Table 1

Interrater Reliability

Non-Pitch Rhythms						
Rhythm	1 D/R	2 T/R	3 D/N	4 T/N	5 LD/R	X
% Agreement						
Graphic	100.0	94.4	93.0	95.8	100.0	96.6
Numeric	97.2	97.2	95.8	91.7	97.2	95.8
Accuracy	100.0	100.0	100.0	100.0	100.0	100.0
Grouping	97.2	97.2	100.0	100.0	97.2	98.3
Symbol	100.0	100.0	100.0	100.0	100.0	100.0
Average % agreement for non-pitch rhythms:						98.1

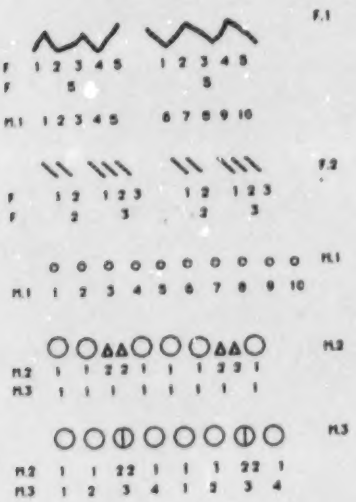
Drumming Representations			
Melody	Duple	Triple	X
% Agreement	91.7	94.4	93.0

Metric Hierarchy with Spatial Analogs			
Melody	Duple	Triple	
% Agreement	94.4	95.8	95.1

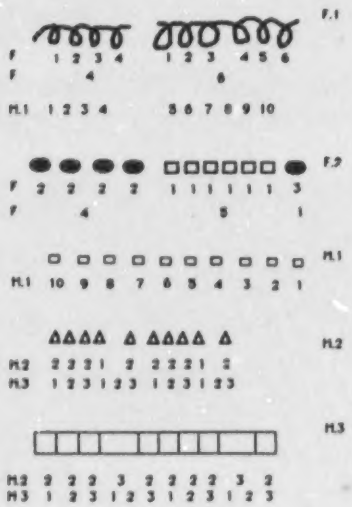
Overall % Agreement:	97.59	(N = 29)	96.97	(N = 7)
Range:	91.7 - 100.0			
Standard Deviation:	2.76	(N = 29)	2.61	(N = 7)

Figure 8. Graphic and Numeric Descriptions of the Non-Pitch Rhythms

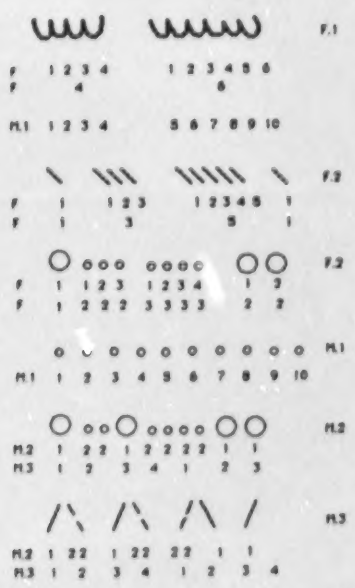
Duple Repeated Motif



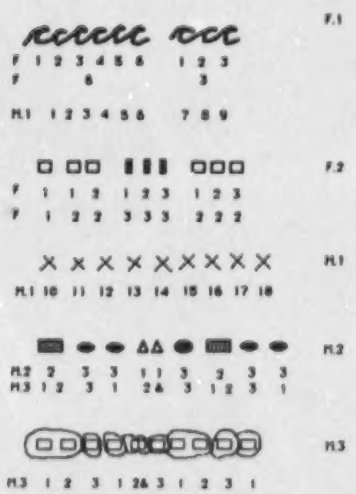
Triple Repeated Motif



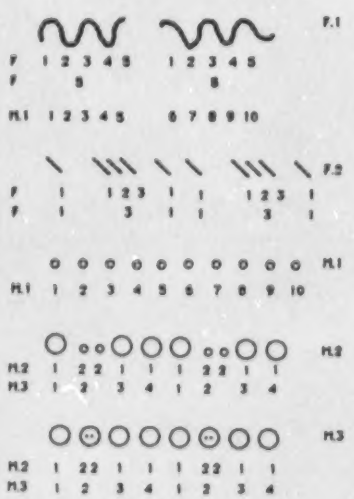
Duple Non-Repeating Motif



Triple Non-Repeating Motif



Last Duple Repeated Motif



Figural: F.2) are characterized by their emphasis on figural groups, highlighting how the events of the rhythm pattern seem to cluster together. Early Figural drawings depict the major figures and the number of events in the pattern. The child actually "plays" the rhythm on the paper with the pencil, lifting the pencil when one figure stops and putting the pencil back down when the next figure begins. Thus, the events within a figure are described by a single continuous mark. Usually the Early Figural drawings do not depict changes in duration, since the changes in durations are "played" rather than described graphically.

True Figural drawings are made up of discrete marks for each event in the sequence. The marks vary according to duration, but not consistently. One mark may depict different durations, depending on the function of the particular events in the figures in which they appear. For example, a small mark may be used to depict a long duration if the note occurs at the end of a figure and the same mark may be used for a short duration in the middle of a figure. Thus, True Figural drawings can be used to reconstruct the number of events in the rhythm, as well as the actual rhythm, if the "reader" knows the particular description type and is able to read accurately from a True Figural description.

The three types of metric drawing (Counting: M.1, Durational: M.2, and True Metric: M.3) depict all of the events using a discrete mark for each event. They vary in terms of complexity and type of measured durational relationships depicted by the description. The simplest type of metric drawing, the Counting drawing, does not differentiate different durations, but merely records the number of discrete events with identical marks for each event. Neither the figural groups nor the metric durations are depicted.

Durational descriptions are characterized by the same type of mark for like durations, regardless of where the events occur within the sequence. However, one mark cannot be measured with a different kind of mark (e.g., a mark twice as long as another does not mean that the longer mark stands for an event which has twice the duration of the event depicted by the shorter mark).

Finally, True Metric drawings not only use consistent symbols for each of the durations, but the symbols themselves can be mathematically related to one another to determine the relative durations for each of the surface events, based on a fixed reference unit. For example, a square may be used as a unit, and therefore two half-squares would denote two equal events which occur in the time of a square. The fixed reference unit is constructed by the child upon reflecting on the durational relationships in the rhythmic sequence.

Numeric descriptions were similarly judged. Numeric descriptions were classified as figural (one type) or metric (three types, corresponding to the three types of metric graphic descriptions).

Figural numeric descriptions depict the number of events in each of the figures. The child "counts up" the number of events in each figure. A new count is started for each figure, and so, each event is described in terms of its position within the figure. The child may use one number for each figure adding up to the total number of events in the figure. Alternately, the child may use one number for each mark in the figure, beginning a new sequential count for each figure.

The Counting metric description is made by counting up the number of events in the entire sequence. The numbers are sequential, that is, the first symbol might be marked '1', the second '2', and so on. As for the

Counting graphic description, each element is treated as the same except for its position in the sequence, regardless of its duration or function in a figural group.

For the Durational metric description, the child assigns the same number to like durations, that is, a given number denotes elements which belong to the same durational class. For example, a '2' might be used to describe all of the 'short' events, and a '3' might be used to describe all of the 'long' events. However, the values of the numbers cannot be numerically compared to each other. In the example given, a '3' is not to be interpreted as "one and a half times as long as '2'".

Finally, for the True Metric numeric description, the child uses the numbers to show the relative durational values of all of the events in the sequence, in terms of the values of the numbers. There is an interval relationship between the numbers, so that '4' means 'twice as long as 2'. The child is therefore referring to an invariant time-unit by this kind of numeric description, by which the proportinal relationships between the various durations can be measured. The use of True Metric numbers, just as for the True Metric graphic description, indicates that the child has constructed a unit which underlies the varied surface durations of the rhythmic sequence.

In addition to scoring the graphic and numeric descriptions as iconic, figural, or metric, the drawings were scored for accuracy (a yes/no score according to the type of description) symbol type (arbitrary or musical), and indications of figural groupings (use of devices to show groups, e.g., space, commas, barlines, etc., regardless of the form of description).

Drumming Representations

Drumming descriptions were classified as iconic, figural, or metric

(two types). Figure 9 gives likely descriptions for the duple and triple metric hierarchies.

Iconic descriptions are pictures of the activity rather than of the hierarchy of beats. For example, the child might draw a picture of a single drum, or a picture of a lady with curly red hair. No information about the beats can be reconstructed from iconic descriptions.

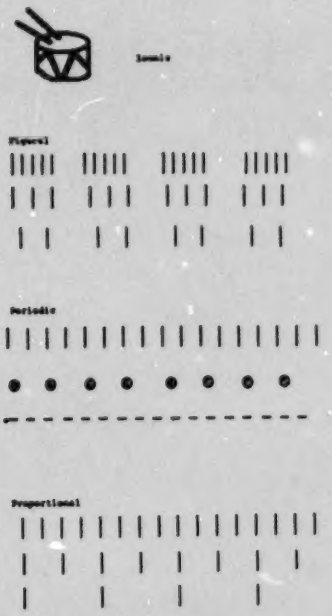
In the Figural drumming descriptions, the child attempts to show the periodic, invariant nature of each of the beats. However, the beats are not described consistently, nor can they be measured in terms of each other. Rather than drawing an invariant system of beats, with evenly spaced marks denoting equal time intervals between events, the description is of groups of evenly spaced marks. The groups of beats correspond to figural groups in the melody. The child stops drawing periodic events at the end of a figure, and commences drawing periodic events once again at the beginning of the next figure.

The two types of metric descriptions of drumming (Periodic: M.1, and Proportional: M.2) both describe the invariant nature of the beats. The Periodic drawings show each beat level as a series of invariant events, by making equally spaced discrete marks to depict equal time intervals between events. A faster beat is therefore shown by marks which are closer together spatially than the marks representing a slower beat. However, the different beat levels cannot be measured with one another. One can tell from the drawing that one beat is faster, as compared with another, but not how much faster in terms of the other beat.

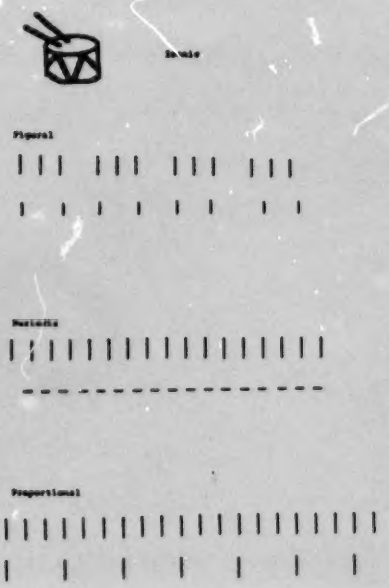
The Proportional descriptions depict beat levels which can be measured in terms of each other. For instance, twice the spatial distance between the marks on one beat level as compared to another indicates twice the time

Figure 9. Drumming Descriptions without Spatial Analog

Duple Melody



Triple Melody



interval between each event from one beat level to the next.

Metric Hierarchy with Spatial Analogs

Metric hierarchy descriptions were classified as iconic, figural, or metric (three types). Examples of the possible metric hierarchy drawings for the duple and triple melodies are given in Figure 10.

The criteria for scoring the Iconic, Figural, Periodic, and Proportional drawings of the metric hierarchy with the spatial analogs of the melodies are the same as for the drumming descriptions. In addition, the True Metric (M.3) description was scored. The True Metric description consists of a hierarchical system of evenly and proportionally spaced marks, which correspond to the metric hierarchy generated by the varied surface durations. In addition, the marks used to depict the metric hierarchy coincide or line up with the marks of the spatial analog of the surface events. The durations of the surface events can therefore be measured against the durations of each of the levels of the metric hierarchy.

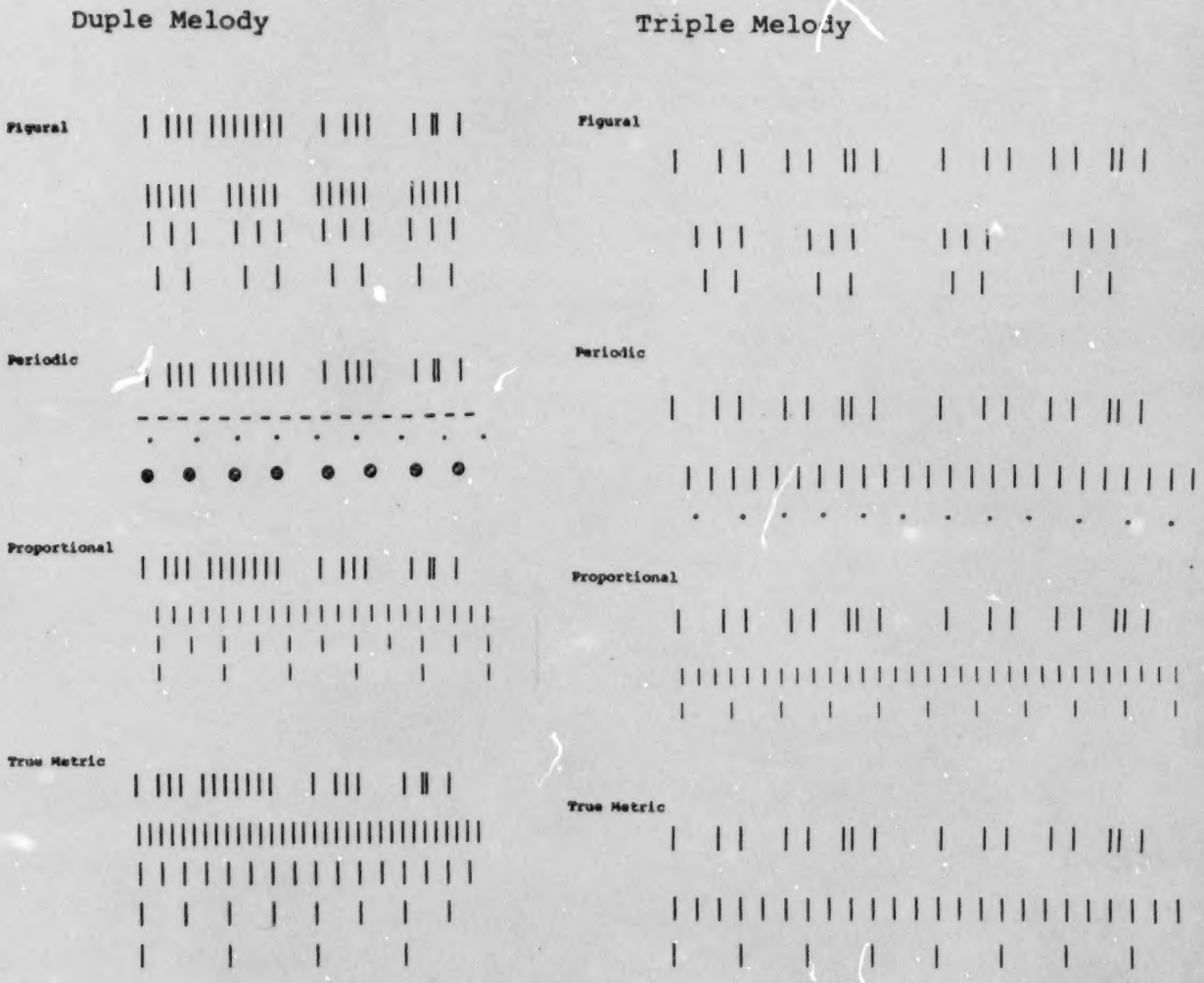
Motoric Abilities

Producing the Metric Hierarchy

A good beat-keeping score (1) indicated that the child was able to keep time to the melody without difficulty, on his own, or with minimal prompting. Good beat-keeping was also indicated when children were able to maintain the beat despite surface durations which were of a longer duration than the beat events.

A fair beat-keeping score (2) indicated that the child was able to keep time to the melody with difficulty. Either the child needed several passes at the melody before he was ultimately was able to maintain a beat, or the child could not maintain a beat he found initially, or the child

Figure 10. Drumming Descriptions with Spatial Analog



kept a steady beat which did not "fit" or underly the surface durations of the melody.

A poor beat-keeping score (3) indicated that the child was unable to keep time with the melody, even with substantial matching, demonstrating, and prompting by the experimenter. Children who scored poorly for beat-keeping were usually unable to maintain a steady beat, and may even have been unabl to mark time without music.

In some cases, children repeated a short pattern of varied durations when asked to find "another beat". For example, for the triple original melody, children often repeated a two-note pattern made up of quarter note and a half note. This sequence was congruent with the surface durations and was scored in the same manner as were the evenly clapped invariant beats. The actual pattern clapped by the child was noted, and then the experimenter asked the child to "clap another steady beat".

The drumming scores for each beat for each melody were compiled on a five-point scale, so that each subject received a composite drumming score to reflect their overall drumming ability for all of the melodies, where a score of 1 represented excellent drumming ability, and a score of 5 represented poor drumming ability. (1 [excellent] = "1" for all 12 beats; 2 [good] = "1" for at least 8 "1s"; 3 [fair] = 5 - 7 "1s"; 4 [below average] = 1 - 4 "1s"; 5 [poor] = no "1s".)

Aural Abilities

Identifying Congruent Beats

The beats which the child identified as "fitting" with the duple and triple melodies were noted. Of these, the number of congruent beats identified for each melody were determined. It was noted whether the child's favorite beat was congruent.

Description-Reading Abilities and Preferences

Drumming Descriptions

The explanation given by the child for the proportional drawings was scored as Intuitive, Periodic or Proportional.

Intuitive explanations were marked by the attention given to the number of symbols for a beat description, rather than to the spatial relationships among the symbols. Thus, the child would say that the drawing with closely spaced symbols was "faster because there are more". Even when the representation was re-drawn so that there were more "slower" events, that is widely spaced marks, the child would insist that the one with more was faster, regardless of the spacing between symbols.

Periodic explanations recognized that the further apart the symbols appeared spatially, the slower the beat. However, periodic explanations did not relate the beat levels to each other, except in relative terms such as "faster" and "slower".

Proportional explanations were characterized by a measurement statement comparing the levels of the hierarchy, for example, "that one's twice as fast because there's two of those for every one of those".

Duple Repeated Motif

The children were rated on their ability to clap from their own drawings, using a three-point scale similar to the one used for drumming ability. Subjects were judged for the accuracy of their clapping with respect to the drawing and with respect to the actual rhythm. They were similarly rated for clapping of other descriptions. Comments were noted.

A score of 1 (good) indicated that the child clapped the rhythm without error. Both metric and figural interpretations could receive a score of 1, as long as the child used the same interpretation for the whole

sequence. Thus, figural descriptions could be clapped metrically, and vice versa. A score of 2 (fair) indicated that the child made a minor error in clapping, for example, missing an event or making one or two durational inaccuracies. A score of 3 (poor) was given if the child made a major error in clapping, for example, missing more than three events or making five or more durational errors.

An average score for the reading of figural descriptions and the metric descriptions was calculated. It was also noted if the child was able to understand both forms of description equally well, that is, if he or she had the same average clapping score for both kinds of descriptions.

The descriptions that the child identified as "most helpful" and "least helpful" for depicting the rhythm were identified according to type (F.1, F.2, M.1, M.2, or M.3).

Duple Non-Repeating Motif

The child was scored for clapping accuracy for guessing the "mystery rhythm", and the description(s) used to guess the rhythm were noted according to type (F.1, F.2, M.1, M.2, or M.3). The child's clapping ability for the other descriptions, not used to guess the rhythm, was also assessed. Average figural and metric scores were calculated, with the Early Figural (F.1) and Counting (M.1) descriptions omitted from the average. As for the duple repeated motif rhythm, it was noted if the child was able to understand both forms of description equally well. Finally, the representation that the child found the "most helpful" for guessing the rhythm was identified according to type (F.1, F.2, M.1, M.2, or M.3).

RESULTS

Quantitative analyses were made using non-parametric statistics, taking into account the multivariate nature of the data. A composite

protocol analysis was used to qualitatively describe the data.

Quantitative Analysis

The results from the hypotheses based on comparisons between groups (by age or training) appear in Table 2 (See Appendix A for raw data). The significance of the findings are described below.

Descriptions and Reading Ability for Simple Rhythms

The hypotheses regarding the description and reading of simple rhythms led to several significant findings. First, it was found that accuracy in description (using all five rhythms in the sample) increased as a function of age (Chi-Square, 4 d.f. = 26.527, P = 0.0001) but not training (P = 0.1216, N.S.). Thus, the older children were the most likely to desribe the rhythms accurately. The children displaying the greatest difficulty in the description task, predictably, were the seven-year-olds without training. Most of their descriptions were icons or the most primitive metric form.

The level of description, where the descriptions were classified as ordinal (I, M.1, F.2, M.2, M.3; F.1 was treated as equivalent to F.2 since there was only one F.1 description), increased as a function of age (Chi-Square, 4 d.f. = 23.788, P = 0.0001), but not training (P = 0.3203, N.S.). Therefore, while one could predict rising sophistication in descriptions as a function of age, the same relationship was not found with training.

The ability to read descriptions of someone else's making, both figural and metric, increased as a function of age (Binomial regression, Ci-Square, 5 d.f. = 20.49, P < 0.0001). This is in line with children's school experiences. Older children have had more exposure to symbol interpretation, including the reading of text and mathematical symbols. In

Table 2

Specific Hypotheses and Results

Hypothesis	Result
Descriptions and Reading Ability for Simple Rhythms:	
1. The level of description increases with age and training.	age: P = 0.0001 training: N.S.
2. Accuracy in descriptions of simple rhythms increases with age and training.	age: P = 0.0001 training: N.S.
3. The ability to read descriptions of both the figural and metric forms increases as a function of age.	P<0.0001
4. Musically trained children favour metric graphic descriptions of simple rhythms more than untrained children, for reading and making descriptions.	N.S.
5. Musically trained children are more likely than untrained children to be able to read both figural and metric descriptions well.	DR: P = 0.00007 DN: P = 0.00002
6. Children who make metric descriptions (DR) are able to read figural descriptions of the same rhythm accurately, even though they are not of the same type as their own.	P<0.0001
7. Musically trained children use figural descriptions more frequently for the most difficult rhythm (TN) as compared with the simplest rhythm (DR).	N.S.
8. A child's own description will usually differ from his or her favorite description.	P = 0.0002
9. A child's own description will usually differ from the first description used to read the same rhythm.	P<0.0001
10. Numeric descriptions will often (more than 40% of the time) be different from the graphic description for the same rhythm.	P = 0.002
11. Nine and ten-year-old children are more likely to use musical symbols than the other children sampled.	P = 0.007
12. Duple rhythms and rhythms with repeated motifs are easier to describe than triple rhythms and rhythms without repeated motifs, as indicated by level of graphic description and accuracy.	level: meter P<0.00001 motif P = 0.003 accuracy: meter P = 0.018 motif P<0.00001

Motor Ability:	
1. Motor ability is not related to training (H_o).	P = 0.0026
2. Motor ability improves with age.	P = 0.0317
3. Motor ability predicts the level of metric hierarchy description.	N.S.
4. Aural ability predicts motor ability.	P = 0.0053
Aural Ability:	
1. Aural ability is not related to age or musical training (H_o).	age: P = 0.0108 training: N.S.
2. Duple melodies are easier for identifying congruent beats than triple melodies.	N.S
Metric Hierarchy Descriptions:	
1. Children who reach the true metric level for the metric hierarchy with spatial analog descriptions are likely to be old (11 or 12) and musically trained.	old & tr: N.S. old: N.S. trained: P = 0.002
2. The level of explanation of the drumming drawings increases with age.	P = 0.0139
3. The level of explanation of the drumming drawings is not related to musical training (H_o).	N.S.
4. The level of explanation of the drumming drawings is not related to drumming ability (H_o).	N.S.
5. The level of sophistication of the drumming drawings (all four) increases with age and training.	age: P = 0.0072 training: P = 0.0021
6. Duple metric hierarchies are easier to describe tha triple metric hierarchies.	N.S.
Changes in Responses:	
1. The last duple repeated rhythm is more accurately described than the first duple repeated rhythm.	P = 0.022
2. Children use arbitrary symbols more frequently for the last duple repeated rhythm than for the first duple repeated rhythm.	P<0.001
3. Children who change from an F.2 graphic description for the first duple repeated rhythm to an M.2 or M.3 graphic description for the last duple repeated rhythm are likely to have musical training.	P = 0.0015

addition, these children have had more musical experiences. Even those children without formal musical training have had more exposure to music through the school music program itself. Thus, it is not surprising that musical reading ability in general would increase as a function of age, whether the descriptions be metric or figural.

It was hypothesized that musically trained children would favour the metric descriptions in their own graphic and numeric descriptions, and in the descriptions of others which they identified as their favorite, and finally, in the description they use first for reading an unknown rhythm. The result was not significant ($P = 0.1646$, N.S.). However, the plot of metric preferences and abilities for untrained versus trained children indicates that the trend, at least, is for musically trained children to favour metric descriptions.

It was also hypothesized that musically trained children would be more likely than their untrained counterparts to be able to read both the figural and graphic forms of description well. Clear support for this hypothesis was found (DR: $Z = 3.795$, $P = 0.00007$, DN: $Z = 4.063$, $P = 0.00002$). One of the most important implications from this finding is that not only are the musically trained children able to read the metric form, but they do not lose the ability to read figural descriptions in the process. In fact, this result, along with several others, indicates that the musically trained children are flexible both in their description-making preferences and abilities. One can also consider the previous result described, namely that musically trained children do not favour the metric form significantly, as evidence for their flexibility and tolerance for the figural form.

A related finding was that children who make metric descriptions of a

rhythm (DR), regardless of their age and training, are able to read the figural descriptions of the same rhythm accurately, even though the figural descriptions are obviously of a different type from their own (binomial test, $P < 0.0001$). Again, this speaks to the ability to read figural forms even though the metric form may be preferred as the first form of description when children are asked to encode a rhythm pattern.

It was expected that musically trained children using a metric form of description (M.2 or M.3) for the easiest rhythm (DR) would change to a figural (F.2) form for the more difficult triple non-repeating rhythm (TN), because the figural form does not require the child to construct a unit beyond the rhythm itself. This was clearly not the case ($P = 0.75$, N.S.).

Another significant finding was that children's own descriptions usually differ from their favorite descriptions of the same rhythm (binomial test, $P = 0.0002$). Similarly, the child's own description usually differed from the first description used to read the same rhythm on another day (binomial test, $P < 0.0001$). Both of these findings indicate that children may be recognizing that the two tasks have different communication purposes. When making their own descriptions, the task is to "write something so that you can remember it", and thus, the child may be encoding the rhythm in such a way as to remind himself or herself of the pattern, but not necessarily for someone else to read. When reading other description forms, however, the child may be looking for a different form, possibly one that he or she views as more standardized or universal.

Many children were gave a different form of description when asked to make a second pass at the rhythms using numbers instead of graphics (binomial test, $P = 0.002$ for more than 40% different). This is in accordance with Bamberger's (1982) findings. The actual patterns of

graphic-numeric descriptions are described fully in the protocol analysis. Suffice it to say at this point that, once again, there is a strong indication of children's versatility in understanding and generating rhythm descriptions.

A hypothesis which was generated on the basis of observations made during the interviews themselves was that there would be a significantly greater proportion of children using musical symbols at nine or ten years (Chi-Square, 5 d.f. = 16.0, P = 0.0007). In fact, this was expected because these children seemed to feel that their descriptions were not correct unless they used musical symbols in the making. However, this finding in terms of statistical significance, should be interpreted with caution. For one, the quadratic function with respect to use of musical symbols does not indicate anything about children under seven or over twelve years of age. Also, the quadratic function may be as a result of the convergence of two processes, rather than a single process which peaks at nine or ten years. However, given the supporting nature of the protocol analyses, it appears that, indeed, this particular age group has a tendency to prefer the musical rather than arbitrary symbol type.

The final hypothesis regarding the descriptions of simple rhythms is that certain rhythms would be easier to describe than others. In particular, it was expected that duple rhythms and rhythms with repeated motifs would be easier to describe than triple rhythms and rhythms without repeated motifs. By examining the type and accuracy of the first four drawings, it appears that this is the case. Using the the number of M.3 drawings as one indicator, there are significantly more M.3 drawings for the duple rhythms ($Z = 4.639$, $P < 0.00001$) and for the rhythms with repeated motifs ($Z = 2.726$, $P = 0.003$). There is a less significant

difference in accuracy between duple and triple rhythms ($Z = 2.244$, $P = 0.018$). However there are substantially fewer errors for the rhythms with repeated motifs ($Z = 4.738$, $P < 0.00001$). The importance of all of these findings, besides differentiating the rhythms along the meter and motif dimensions, is that the ability to describe rhythms, and possibly also to read rhythms, is dependent on the musical context. Thus, other results should be interpreted in light of the situation in which they were found.

Motor Skill

Since the ability to keep time to music was considered almost a 'natural' process, it was expected that there would be no difference found between trained and untrained children in terms of motor skill. This was not the case. In fact, musically trained children were, on the whole, better at the drumming task (Chi-Square, 2 d.f. = 14.275, $P = 0.0026$). Interestingly, it was expected that there would be an improvement in motor skill as a function of age, based on Petzold's (1963) findings. While there was an improvement with age (Chi-Square, 6 d.f. = 13.820, $P = 0.0317$), the age effect was less strong than the training effect, and indeed, would not be significant under the stricter experiment-wise criterion level of 0.002.

It was expected that the better a child was able to produce the metric hierarchy through drumming, the better also would be the description of the metric hierarchy. This was clearly not the case (MHT: $P = 0.4603$, N.S.). Thus, it is possible that one need not be able to produce the hierarchy in order to understand and describe the different hierarchical levels.

It was hypothesized that aural ability would predict motor ability. The reason for this is that in order to produce the hierarchy, one needs to be able to hear congruency. However, the ability to hear congruency does

not in itself imply that the hierarchy can be physically generated. In fact, this may account for the weak relationship found between aural and motor ability. The cells were significantly different under the less stringent criterion level (Chi-Square, 6 d.f. = 18.410, P = 0.0053), but not under the P = 0.002 level.

Aural Skill

It was hypothesized that aural ability would not be related to age or to musical training. That is, by the time children are seven years of age, it was expected that the ability to pick out congruent beats aurally would be well established. The null hypothesis (no difference according to age or training) was not supported in terms of training (P = 0.0594, N.S.), but was supported in terms of age (Chi-Square, 6 d.f. = 16.628, P = 0.0108, N.S. under the stricter 0.002 criterion level).

It was also hypothesized that it would be easier to pick congruent beats for the duple melodies than for the triple melodies. This was not found, using the favorite beat measure as an indicator. In fact, the proportion of favorite beats which were congruent for the two melodies was the same in both cases, 89%.

Metric Hierarchy Descriptions

It was expected that children who reached the true metric level of the metric hierarchy descriptions with the spatial analogs of the melodies would be older (11 or 12) and musically trained. While the training effect was significant (Chi-Square, 1 d.f. = 9.18, P = 0.002), the age effect and age and training interaction effects were not. Thus, the one most reliable predictor for true metric descriptions of the metric hierarchy is training.

It was found that the level of explanation of the alternate hierarchy or drumming drawings provided for the children was more likely to be

explained by age than by training (age: Chi-Square, 2 d.f. = 11.866, P = 0.0184, training: P = 0.7508, N.S.). This is not surprising. Asking the children to interpret the drumming drawings, involves a clear developmental progession. The child begins by attending to some aspect of the drawing which is not indicative of the drummers' beats, but is perceptually salient to the child, i.e., number of marks instead of the spatial distances between marks. As the child grows older, he or she begins to see that it is the spatial distance which indicates the different beats. At the most advanced stage, the child realizes that the spatial distances are proportionally related, and mark the proportional time relationships between the various beat levels. This is much in keeping with the developmental processes identified by the Piagetian school. Thus, the training variable should have little effect, while age should be a good indicator of the ability to interpret the drumming drawings in terms of the drumming activity.

It was expected that the level of explanation of the metric hierarchy drawings provided would not be related to drumming ability, for the two reasons. First, it was found previously that the level of description was not related to drumming ability, that is, the child could describe something which he or she could not physically produce. Thus, the child may also be able to explain a description of something which he or she is unable to physically generate. Second, the explanation of the drumming descriptions provided, as indicated by the discussion above, may be less of a musical task than many of the others, and hence, follow a slightly different developmental process. Indeed, the level of explanation was not related to drumming ability (P = 0.1278, N.S.).

In accordance with the descriptions of the rhythms, the level of soph-

istication of the drumming drawings, both with and without the spatial analogs and for both meters, increased as a function of age and training (age: Chi-Square, 4 d.f. = 14.042, P = 0.0072, training: Chi-Square, 2 d.f. = 12.345, P = 0.0021). The training effect is stronger, since the age effect would not be significant under the stricter criterion level. Thus, the older children and children with training were more likely to use the higher metric forms (M.2 and M.3) than the other possible forms of description.

It was expected that the duple metric hierarchies would be easier to represent than the triple hierarchies. There was no difference found between the two meters. It seems that meter plays a less important role in describing the hierarchy as opposed to describing the relationships between the varied durations of a simple rhythm.

Changes in Responses

The final set of hypotheses deals with the differences in describing the first duple repeated rhythm as compared with the last duple repeated rhythm. To begin with, it was hypothesized that the last rhythm would be described more accurately than the first, even though both rhythms were very similar in construction. The hypothesis was supported (McNemar Test for matched pairs, Chi-Square, 1 d.f. = 5.263, P = 0.022), although not under the more stringent 0.002 criterion level. The increase in accuracy may have been caused by a number of factors, including a practice effect, an effect from the intervention (seeing alternate forms of description may have taught the children something about their own description making), or the choice of a description type and symbol form which was more appropriate than their first choice, given the range of options to which they were exposed during the intervening period.

It was also hypothesized that children would use arbitrary symbols

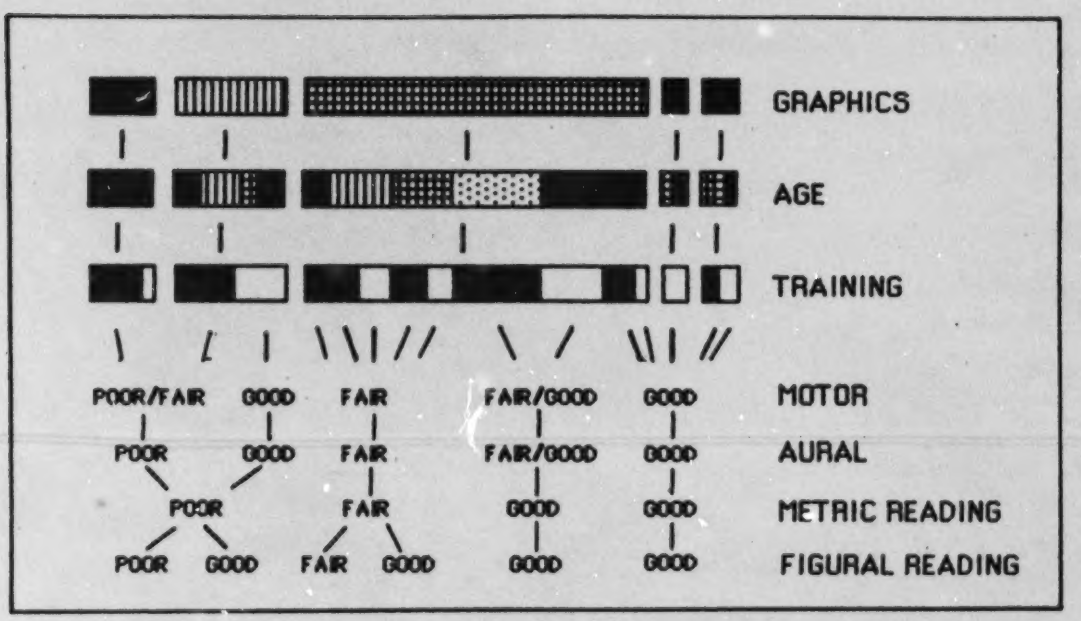
more frequently for the last duple repeated rhythm. This hypothesis was supported, as many children changed from the musical to arbitrary forms (McNemar Chi-Square, 1 d.f. = 14.450, $P < 0.001$). Again, the reasons for the change could be several. For one, the children may simply have felt more at ease using arbitary symbols as opposed to musical symbols after seeing many alternate description forms, all using arbitrary symbols. Also, the children may have picked up an arbitrary form which they had not previously thought of, and decided to use the same form in their final drawing.

The final hypothesis regarding change was directed towards the musically trained group. It was expected that children who changed from a figural (F.2) form of description for the first duple repeated rhythm to a metric form (M.2 or M.3) for the last duple repeated rhythm were more likely to have had prior musical training. The hypothesis was supported ($Z = 2.975$, $P = 0.0015$). This indicates that while musically trained children may prefer to use a figural form when given one opportunity to represent a rhythm, they are more readily able to switch to the metric form, once the metric form has been presented to them. That is, while these children may not show their knowledge of the metric form in all of their descriptions, it appears that they have the underlying, although sometimes hidden ability, to describe rhythms metrically if they so choose.

Individual Patterns

The probable paths taken by an individual subject are graphically related in Figures 11 to 13. Figure 11 shows what can be predicted about a child's motor, aural and reading abilities, given information on his or her graphic description of the duple non-repeating rhythm, followed by knowledge of the child's age and musical training. Figure 12 begins with

Figure 11. Patterns Among Responses Given Graphic Description



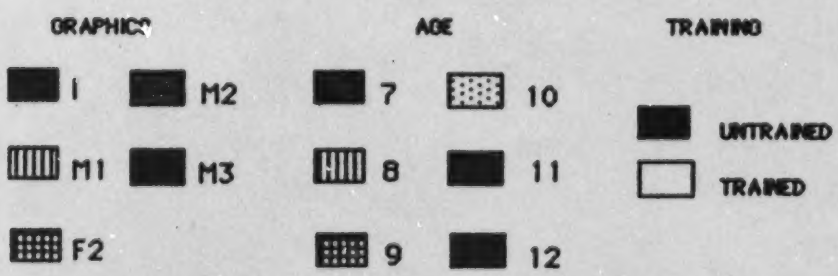
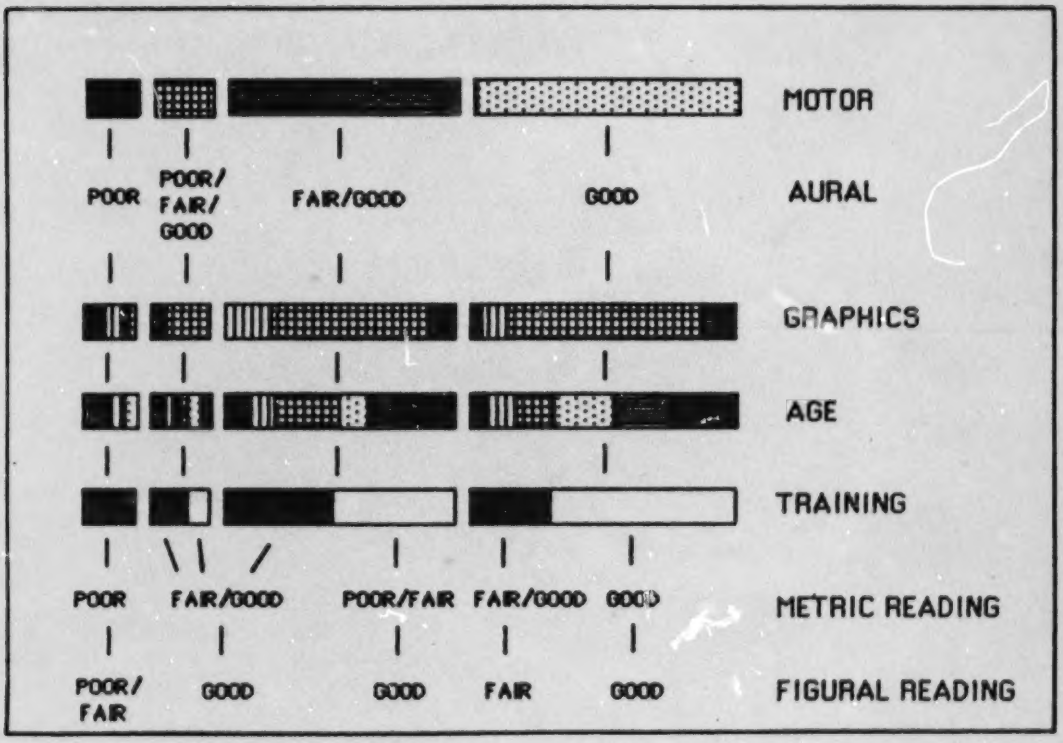


Figure 12. Patterns Among Responses Given Motor Score



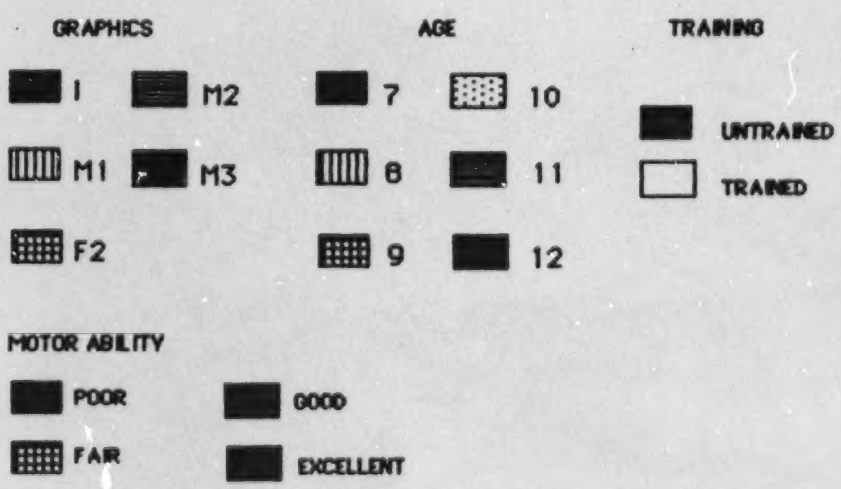
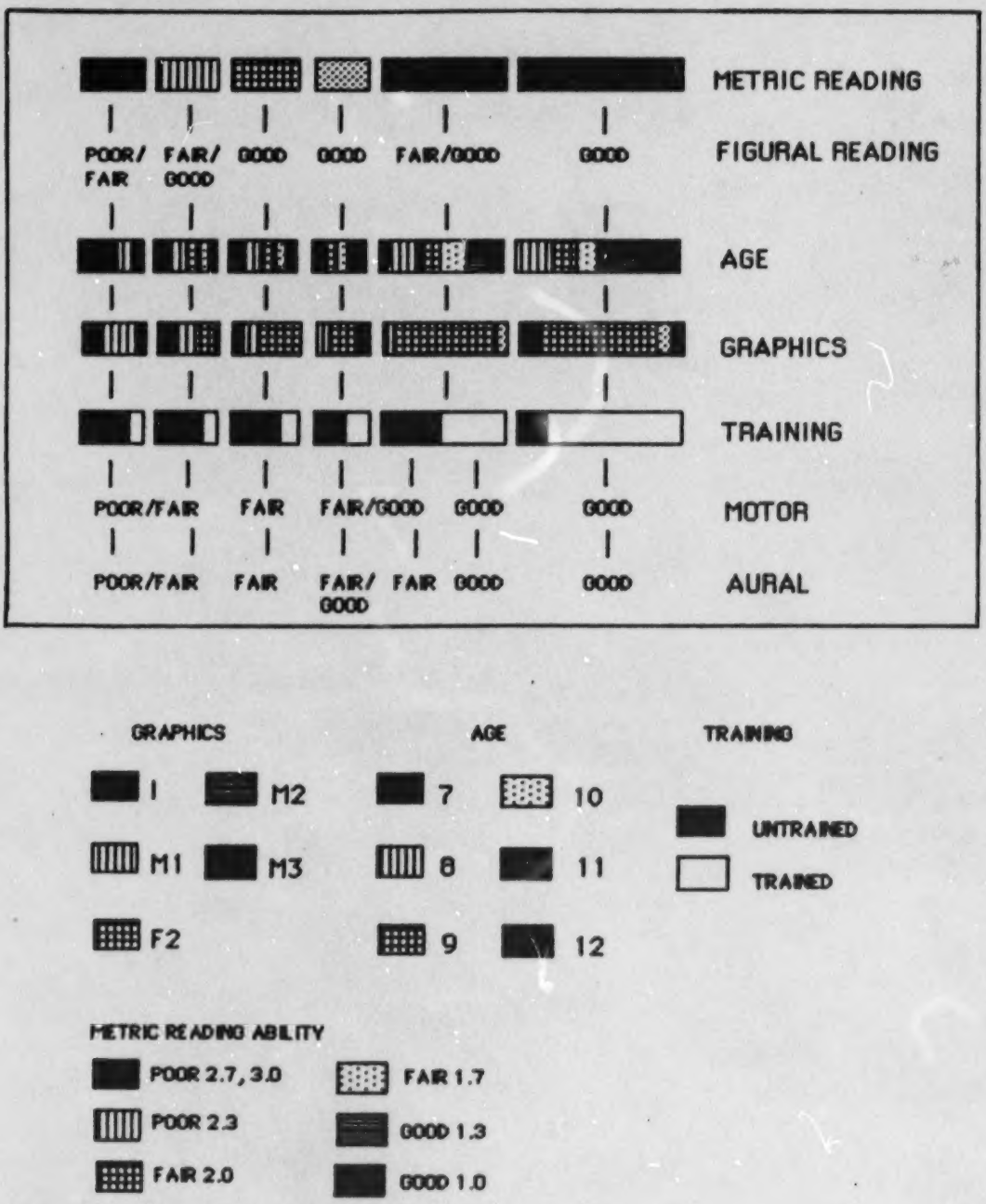


Figure 13. Patterns Among Responses Given Metric Reading Score



information on the child's motor ability, from which predictions on the remaining response variables can be made. Finally, Figure 13 shows how the child's ability to read metric descriptions can be used to predict ability for reading figural descriptions, preference for describing rhythms, and motor and aural abilities. In each case, the proportions of each level of the response variables are given, and the most probable paths are indicated by arrows, once again using proportions as the basis for describing the probable paths.

The results of the cluster analysis support the graphic illustrations. The data set of forty-seven measures was reduced to seven variables. The two factor variables, age and training, were retained. Five response variables were chosen to represent each domain and type of task. Thus, the score on the graphics for the duple non-repeating rhythm, the motor score, the proportion of congruent beats identified for the duple melody, and the reading ability for the metric and figural descriptions the duple non-repeating rhythm were selected as response variables. Cluster analysis was applied even though one of the assumptions of cluster analysis is continuous data. Thus, the cluster analysis should be regarded as a summary of the patterns in the data set, rather than as conclusive proof of clsters for the subject population.

Ward's method is used to describe the patterns of responses, using the results from the unstandardized data. The first cluster was made up of observations 1 - 12, 16, and 21. These children are all young (7 or 8 years of age) and most of them have musical training. The graphic descriptions generated by these children are varied, but tend to be of the more primitive forms (I, M.1, F.2). The children also vary somewhat in their reading ability, mostly in the moderate range. Only one child in

this cluster was able to read both forms well. Most are moderate to poor readers of metric descriptions. On the whole, these children are able to read figural descriptions well. The children belonging to this cluster have good motor skills. One of the most distinguishing features of the children in this group is that they have poor aural ability. On average, only 60% of the beats that were thought to be congruent by these children were, in fact, congruent.

The second cluster was comprised of observations 13 - 15, 17 - 20, 22 - 37, 40, 41, and 43 - 48, and 54 and 57. This is the largest cluster, and represents the greatest variety of responses of all of the clusters. The children in this group range from eight to eleven years of age, and are from both the musically trained and untrained groups. Classifying the children from this cluster further into two sub-groups according to age and training helps to clarify the patterns.

One sub-group is formed by the eight- and nine-year-old children. Most of these children are fair-good readers of the metric form, and good readers of the figural forms, regardless of training. However, they differ in motor and aural abilities according to training, with the trained subjects performing better in both the motor and aural domains. The graphic descriptions produced by these children are approximately evenly divided between the M.1 and F.2 forms.

Another sub-group is made up of the ten-year-old children and two eleven-year olds, most of whom are trained. Again, as with the eightand nine-year-olds, those children with training tend to have excellent motor and aural skills, and are able to read both metric and figural descriptions well. These children are somewhat distinguishable from their younger counterparts in that their graphic descriptions are slightly more

sophisticated: there are less M.1 drawings, and more of the higher level metric drawings, both for the duple non-repeating rhythm and the others which were not included in the cluster analysis.

The last cluster included observations 38, 39, 42, 49 - 53, 55, 56, and 58 - 72. Most of these children are eleven- or twelve-years-old, with the exception of observations 38, 39, and 42. The ten-year-olds included in this cluster are unusual, however, in that while they are all untrained, they nevertheless have excellent aural, motor and reading skills. For this reason, these children are similar to the older children in this cluster. The eleven- and twelve-yearold children, regardless of training, tend to have good or excellent motor and aural skills, are able to read both forms of description well, and generate mixed high level descriptions (F.2, M.2, and M.3).

The clusters indicate that one of the strongest predicting variables is age. In some cases, the training variable also defined clusters, particularly where the motor and aural responses, and metric reading abilities were involved. This conforms with the analyses described in the following section. A summary of the characteristic responses for each cluster appear in Table 3.

Protocol Analysis

The findings from the protocols are discussed in terms of a particular theme. Six themes are featured in the protocol analysis in the present paper. These themes are neither mutually exclusive nor exhaustive, but serve to illustrate the nature of the children's understanding of rhythmic structure.

Use of Number

It was shown in the statistical analysis that children's graphic and numeric descriptions rarely coincided. While this leads to the important

Table 3

Description of Clusters

Cluster 1: 1 - 12, 16, 21

- 7 or 8 years old
- trained
- good motor skills
- poor aural skills

- I, M.1, F.2 graphic descriptions
- fair or poor metric readers
- good figural readers

Cluster 2: 13 - 15, 17 - 20, 22 - 37, 40, 41, 43 - 48, 54, 57

Sub-group 1:

- 8 and 9 years old
- trained and untrained
- fair motor and aural skills for untrained children
- excellent motor and aural skills for trained children

- M.1 and F.2 graphic descriptions
- fair or good metric readers
- good figural readers

Sub-group 2:

- 10 years old
- trained
- excellent motor skills
- excellent aural skills

- F.2 and M.2 graphic descriptions
- good metric readers
- good figural readers

Cluster 3: 38, 39, 42, 49 - 53, 55, 56, 58 - 72

- 11 or 12 years old
- trained and untrained
- excellent motor skills
- excellent aural skills

- F.2, M.2, M.3 graphic descriptions
- good metric readers
- good figural readers

conclusion that children are capable of making two different descriptions of the same rhythm, the statistical analysis does not indicate what types of graphic-numeric combinations emerge, nor lead to speculations about the possible cognitive processes underlying the choices.

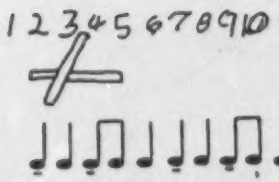
There were a limited number of graphic-numeric combinations (see Figure 14). For example, children who made metric graphic descriptions (M.2) might attach numbers indicating the figural groups (F). Another frequent combination was to use figural graphics (F.2) indicating one level of figural grouping, and using numbers to indicate another level of figural grouping. In these cases, children highlight a different aspect of the rhythm in their "second pass" using numbers.

Some children who used the true metric (M.3) type of graphic description used a less sophisticated metric numeric description (M.2). This finding, where a high level graphic description was combined with a lower level numeric description of the same type, that is, figural or metric, also occurred with the figural drawings and numbers.

The types of combinations which did not emerge were a mixture of low level graphic and high level numeric descriptions. Thus, an F.1 graphic with an M.2 numeric description or an M.1 graphic with an F.2 or M.2 numeric description did not occur. While there was one instance of a child making an iconic drawing and using M.3 numbers, the most extreme counter-example to the claim that levels are not mixed, it appeared that this was due to his use of number as a classification label for the icons (notes), rather than from an understanding of the underlying unit of metric notation.

Thus, on the whole, the findings indicate that there is some kind of parallel development between the figural and metric modes. That is,

Figure 14. Common Graphic-Numeric Combinations

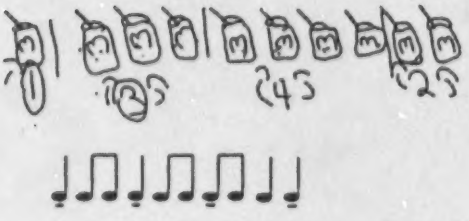


7:4 musically trained female
I-M.1 description

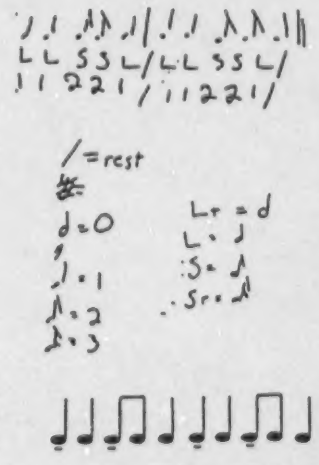
10:5 musically trained female
F.1-M.1 description

10:5 untrained male
F.2-F description

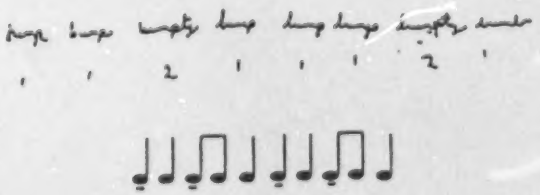
9:11 musically trained male
M.3-M.3 description



8:5 musically trained female
F.2-F description



12:2 musically trained male
M.3-M.2 description

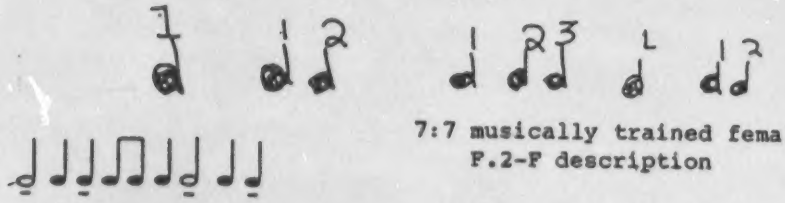


11:5 untrained male
M.2-M.2 description

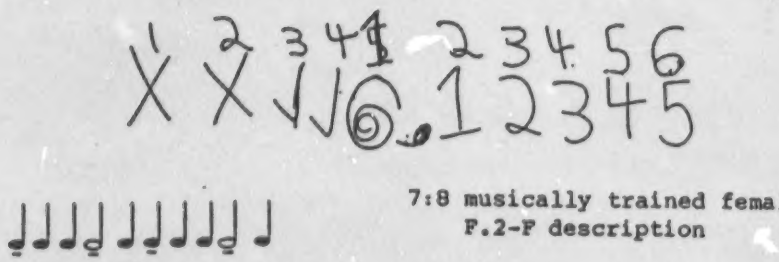
children may be able to understand and describe the two different modes, but only at approximately the same levels. Also, if one form of description is on a higher level than the other, the tendency is for the graphic description to be more advanced. For example, the graphic M.3 - numeric M.2 combination indicates that while the child may be familiar enough with the metric notation (usually standard music notation) to graphically produce an M.3 drawing, he or she may as yet be unable to numerically describe the underlying unit.

The most varied numeric descriptions accompanied the true figural (F.2) drawings. These included figural numbers depicting different levels of figural groups (F), numbers depicting durations (M.2), numbers based on the possible pitches that could accompany the non-pitch rhythms (S), numbers that reflected the sound of the figural groups rather than counting the elements in each group (S), and ambiguous numbers, either depicting figural groups or classifying look-alike symbols through the use of number (A). Examples appear in Figure 15. This variety in use of number is notable for several reasons. For one, the differences between an F.2-S and an F.2-A combination reflect entirely different approaches to the use of number. In the first case the child is attending to some feature of the rhythm itself, while in the latter, the child may be classifying objects - long sticks and short sticks - which is a use of number removed from the original rhythm. The different uses of number, especially for the F.2 graphics, also indicates that these children are able to produce more variety of description than children who use metric graphics of the same level. This may be due, in part, to the nature of the F.2 graphic description, which lends itself to more varied numeric descriptions, than, for example, the less sophisticated F.1 form. Although the M.2 graphic

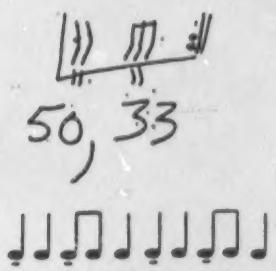
Figure 15. Numeric Descriptions in Combination with True Figural (F.2) Graphic Descriptions



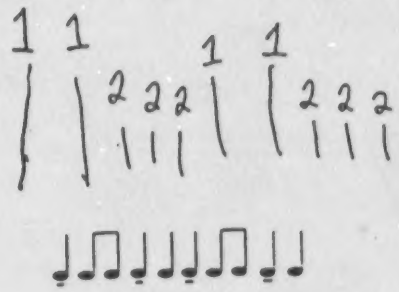
7:7 musically trained female
F.2-F description



7:8 musically trained female
F.2-F description

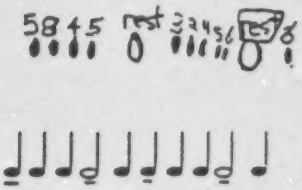


11:11 musically trained male
F.2-Sound description



10:7 untrained male
F.2-Ambiguous description

12:1 untrained male
F.2-M.1 description



8:11 untrained female
F.2-Sound description

form gives as much information as the F.2 form, although different, the child is more likely to give metric numbers since he or she is already thinking in metric terms when making the graphics, and is likely to continue to do so when adding numbers. Thus, the choices for numbers with the M.2 graphic form become more limited. Because children making F.2 graphics seem to be less fixed in terms of numeric description, they may also be the most open to learning other forms. This is vitally important, for both musically trained and untrained children are capable of making and reading F.2 descriptions. Therefore, arguably both groups are capable of producing and presumably learning other description forms, including conventional music notation or new figural forms.

Use of Symbol

One of the quantitative findings indicated that the use of musical symbols for describing simple rhythms peaked when children were eight to ten years of age, regardless of training. From an examination of the protocols, this appears to be partly a function of eight- to ten-year-olds' concern with "doing it right". A number of the these children, even those without prior musical training, expressed the view that "if it's music, I gotta use notes, right?", despite assurances that "any kind of mark would be fine". The older (eleven- and twelve-year-olds) and younger (seven-year-olds) children seemed much less concerned with the choice of symbol, using whatever seemed natural to them. In fact, many of the older children with prior musical training chose to depict the rhythms using arbitrary symbols because it was "easier than using notes".

Children of the nine and ten year age group were also hesitant to use a symbol they had been shown during other tasks, prefixing their use of a "borrowed" symbol by the following kinds of comments:

"Can I do something like what you showed me?"

(10 yrs. male untrained; regarding metric hierarchy/spatial analog task)

"I'm going to use someone else's idea for this."

(9 yrs. female untrained; regarding last duple repeated rhythm)

Similarly, after seeing arbitrary symbols, children occasionally needed to justify to themselves and to the experimenter that they could still use standard music notation, as if the new "correct" symbol form was an arbitrary one. Excerpts appear below, indicating that these children view music notation as the correct form. However, this does not necessarily imply that they recognize that the conventional music notation depicts the metric mode.

"I think I'm still hooked on notes."

(10 yrs. male trained; regarding last duple repeated rhythm)

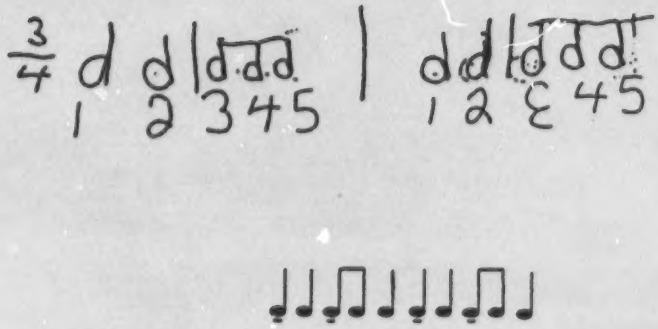
"I still like the notes though. 'Cuz I know you understand them."

(10 yrs. female trained; regarding last duple repeated rhythm)

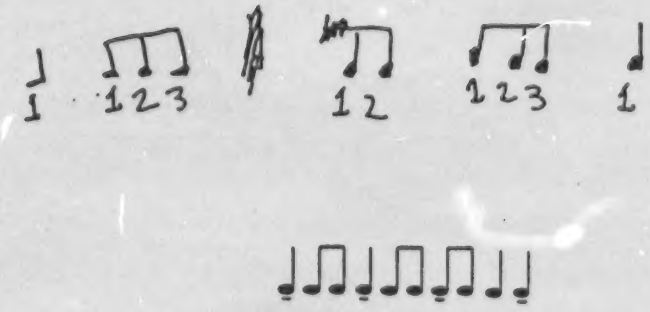
Not surprisingly, children who used musical symbols nevertheless often made figural descriptions, as illustrated in Figure 16. Some of them used elaborate standard notational trappings, including time signatures and barlines. Even so, their descriptions were clearly figural.

It might be that the use of musical symbols leads to errors in description, especially when the children are not experienced in using standard music notation. Because musical symbols are more cumbersome than arbitrary symbols such as simple strokes or dots, sometimes children made errors simply because the time spent making the notes caused them to lose track of the rhythm. This claim is supported in part by the children's

Figure 16. Figural Descriptions Using Musical Symbols



3:10 untrained female
F.2-F description



9:7 musically trained female
F.2-F description

choice of symbol for the last duple repeated rhythm. After seeing other descriptions using arbitrary symbols, many children abandoned the use of musical symbols, and accuracy increased. (However, it is true that accuracy may have also increased because children were becoming more skilled at reading and writing descriptions through the course of the interview.)

By contrast, where symbol choice was based on the rhythm and task rather than on choosing what was perceived to be the "correct" symbol, flexible and meaningful choice of symbol was made. One of the clearest examples of this highly flexible use of symbol was provided by Lori, a seven-year-old musically trained child. She showed the greatest variety in use of symbol, appearing to be highly sensitive to the factors influencing choice of symbol in general - the kind of infomation she was trying to convey, the conventional use of symbols, and the person who would be most likely to read her description. Sometimes she used arbitrary symbols, sometimes she used meaningful icons (e.g., drums), and sometimes she used standard music notation. Her choices for symbols were deliberate, as indicated by the following dialogue as she was choosing her symbol for the drumming descriptions. From her comments, it appears that Lori had decided how to place her marks spatially before deciding what symbol would be appropriate. She had already used different symbols, including arbitary icons and musical notation, but when faced with a new task, she sought a newly appropriate symbol.

L. For the fast one, could I put them closer together?

R. Yes, you could.

L. Only, I don't know what to put closer together.

Lori chose a drum as a symbol. The drums were then arranged spatially to indicate the different drumming rates. The symbol was a clumsy one, taking a long time to draw. However, Lori managed to capture the invariant nature of the drumming with her symbol, as well as representing the drumming activity by choosing to draw actual drums.

When Lori had to invent a musical symbol, she carefully explained her choice. She only explained how her symbols were to be interpreted when she used standard music notation. This can be taken to indicate that she realized there were conventions with the use of music notation, and that she wanted to make the connection between her use of the symbols and the commonly accepted conventions.

> L. (to depict two eighth notes and a quarter as a figural group, Lori chose to join together three eighth notes) Well, I think it should be like this. But I haven't seen any of these in my piano notebook yet.

Perhaps the strongest general implication arising from the children's choice of symbol is that the child's view of what is "right" strongly affects their mode of description and therefore the effectiveness of communication. Children who have the confidence to choose symbols which they know they are capable of using to describe the rhythm are more likely to convey the metric and/or figural information accurately than those children concerned with using the "right" symbols. One can only wonder how often children let the "get it right" syndrome obscure the understanding that they might otherwise be able to communicate.

Indications of Figural Groupings

On the whole, most children gave clear indications of the figural groups, regardless of whether the form of description was metric or figural.

The figural descriptions, by their very nature, indicate how the

rhythms fall into figural groups. Interestingly, children often used more than one method of portraying the figural groups, as if to exaggerate the groupings they perceived. Groupings were indicated by several means, including spaces, commas, apostrophes, and change of symbol. Examples where more than one method is used are given in Figure 17.

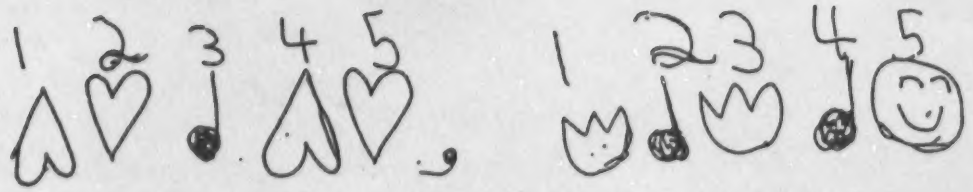
It was found that even children who made highly metric descriptions of the rhythms (M.3 True Metric level) still indicated the figural groupings. As with the figural graphics, these children used spaces and commas for showing the figural groups. However, they also used the more conventional notational methods, including barlines and phrase markings. These drawings give the most information of all of the graphic forms, since the durational relationships are expressed consistently and unambiguously, but not at the expense of obscuring the figural groups. Examples appear in Figure 18.

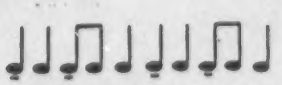
Reading Ability

Most children were surprisingly skilled at reading both figural and metric descriptions of the duple rhythms. In the previous analysis it was shown that many children could read both forms well, and that skill in reading was directly related to age and training, That is, older children and children with musical training were more likely to be able to read both forms well. The age factor may well be an indication of children's growing understanding of alternate symbol forms, based on their longer experience with symbol interpretation in general, such as in language and mathematics.

Contrary to what one might have expected on the basis of Bamberger's (1982) findings, most musically trained children were easily able to read the figural descriptions, especially the sophisticated (F.2 true figural) type. They were also usually able to describe how the two forms of description are related. Often they had difficulty choosing between a

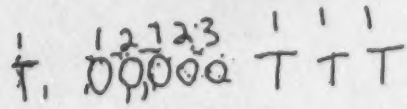
Figure 17. Indicating Figural Groupings in Figural Drawings





7:8 musically trained female

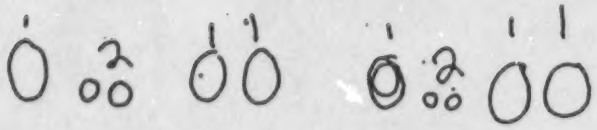
- comma and space used to separate two main figures

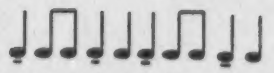


12:2 musically trained male

- change of symbol, comma, and space used to separate figures

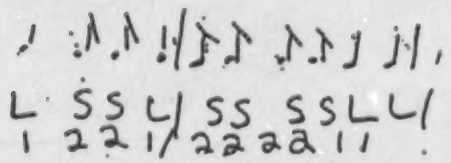
Figure 18. Indicating Figural Groupings in Metric Drawings





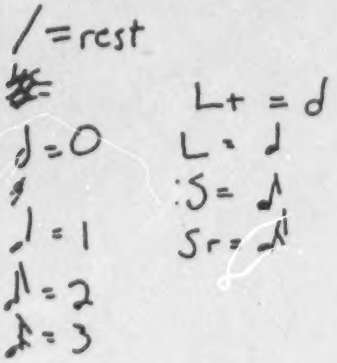
9:10 untrained female

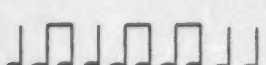
- space used to separate two main figures



12:2 musically trained male

- rest symbol and barlines used to separate two main figures





metric and figural form when asked to pick a favorite, indicating their understanding that there was different information in each description, and that both descriptions were valid. Also, the decision was usually between a figural and metric drawing of the same level, again supporting the view that there is a parallel development between the two modes.

Laurel

Laurel (9 yrs. trained) clapped accurately from her drawing (F.2), which reflected the rhythm accurately. She preferred the F.2 description of the duple repeated motif rhythm, but could relate the metric to the figural, and clap all forms correctly. She was also able to relate the abstract symbols to standard music notation:

> L. Those (large circles) are the quarter notes and those (small circles) are the eighth notes.
>
> L. (Re: F.2 vs. M.2) That could be an eighth note, but they've used a quarter note instead. These could really be different sizes but the same notes [i.e., different symbol, same duration]. They have the same amount of beats between them [i.e., attack times the same], but one has, well, a rest when you use the eighth note.

One can see from Laurel's responses that while she understands the metric forms well, Laurel prefers the figural form for reading and describing the rhythms.

Joseph

Joseph (10 yrs. trained) clapped all descriptions accurately. His own description types were mixed, using F.2 for both triple rhythms and the duple non-repeating motif rhythm, and M.2 for the two duple repeated motif rhythms.

He noted that the M.1 description gave the least information:

> J. I don't understand it. Is it Lori's? It could go alot of ways. You don't

really know what it is.

Joseph identified the M.3 description of the duple non-repeating rhythm as his favorite. This was also the drawing he used to identify the rhythm. However, he seemed to like the figural drawings equally well, stating that "5 and 6 [F.2] are pretty good too". For the duple repeated motif rhythm, he had difficulty choosing between the figural and metric forms:

> J. Do I have to choose just one? Number 1 [F.2] and 3 [M.2] are the best, but I can't really choose one over the other.

James

James (12 yrs. trained) clapped his own description (M.3 with grouping indicated) accurately. He was able to clap the metric and figural descriptions equally well for both duple rhythms. James described some of the relationships among the various forms of description as follows:

> J. (Re: F.2 of the duple repeated motif rhythm) I think they should have a big one at the end [i.e., the last small circles should be large in both groups]. Well, it doesn't really matter...I mean, you can still guess at it.
>
> J. (Re: M.2 of the duple repeated motif rhythm) That's the one I had, except I had stems on.
>
> J. (Re: M.3 of the duple repeated motif rhythm) Well, this one's not exactly like mine, 'cuz there's no barline. Well, I think they're both right [M.2 and M.3], but they should have a barline or something so you can tell where it ends better.
>
> J. (Re: F.1 of duple repeated motif rhythm) Well, a better way using that idea would be like this. [re-draws, using long sticks for the first two sticks for each of the two major figures]. It's a good idea, but you should really have it like this.
>
> J. (Re: M.1 of the duple repeated motif rhythm) There's no rhythm. It's just 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. I'll bet my brother did that one.

The apparently effortless understanding of the sophisticated figural and metric forms that was demonstrated by trained children was also evident in many of the children without prior musical training, particularly the older (ten years and up) children. In fact, if a child could read and write at the F.2 level, it was more likely that he or she would be able to read the M.2 and even the M.3 levels more accurately that the earlier figural descriptions. One child's comment regarding the F.1 description of the duple non-repeating "mystery rhythm" captures his lack of sensitivity to the earlier figural form:

> "What's this? I N W V? I don't understand that one!"
>
> (10 yrs. male untrained; own graphics were F.2, equally good at reading figural [F.2] and metric [M.2 & M.3])

Another important occurrence was the ease with which chidren accepted and understood the explanations of other description forms that they could not immediately read for themselves. This is illustrated by the following excerpt.

Mike

Mike was a nine-year old boy without prior musical training. He was much better at reading the figural descriptions, and his favorite descriptions of the duple repeated motif rhythm were figural. He notes that the M.2 drawing of the duple repeated motif rhythm was "almost exactly the same as mine". Mike commented that the M.3 drawing was "crazy". After having the M.3 drawing explained, he changed his view: "Oh, ...pretty good".

For the duple non-repeating motif rhythm, Mike's first choice was an F.2 drawing, from which his clapping was fair. His favorite was the M.3 representation - a form which he had previously described as "crazy". He

also was able to clap accurately from the M.3 drawing.

The ability to read different forms, the awareness of errors in one's own descriptions, and the ability to alter one's view of a description are all fundamentally important for setting the stage for learning. If children are going to learn to understand standard music notation, it is vital that they be shown different forms of description, and given a chance to relate their own descriptions to the other forms. It would appear that children have strong potential to do just this.

Aural and Motor Abilities

Most children were good at both the aural and motor tasks. All of the children but one were able to mark time, and almost all children could keep time to the melodies accurately at various rates. For the aural tasks, while children did not identify congruent beats in every instance, most of the beats they thought fit with the melodies and their favorite beats were, indeed, congruent.

The most revealing relationships between the aural, motor, and description tasks come from an analysis of the protocols of children who performed poorly on the aural and/or motor tasks. Two such children are now described.

Krista

Krista was a ten-year-old child without prior musical training. She was the only child who was unable to keep time with the melodies. She was also unable to mark time without the melody. She could match the experimenter's beating, but could not maintain the beat keeping on her own. Krista tried to drum the surface durations for all of the melodies. Krista was good at clapping back the non-pitch rhythms.

Krista also had difficulty identifying congruent beats. For the duple

melody, her favorite beat was not congruent, although the other two were. For the triple melody, her favorite beat was congruent, and the other was not. This would indicate that her inability to mark time and keep time to the melodies is related to her inability to hear or identify congruency.

Krista's reading of her own drawing was fair. Krista had difficulty reading other descriptions. She read only one of the duple repeated motif representations accurately, an F.2 drawing. Her favorite duple repeated motif representation was the M.1 drawing - one that she had difficulty clapping and gives the least amount of information about the rhythm. For the duple non-repeating motif rhythm, Krista chose to clap from the F.1 drawing. Her clapping was fair. Again, she read only one of the representations accurately, an F.2 drawing. She had the most difficulty with the M.3 drawing, and found the F.1 drawing the most helpful. Krista therefore not only had difficulty with the reading task, but seemed unaware of when she was reading accurately. This is unusual, since most children were quite good at judging their ability to clap and in picking descriptions which give considerable information about the rhythm. The ability to sense when errors are being made is an important one. Being aware of making errors is important for correcting them - knowing that you are doing something wrong is the first step towards improvement.

Robert

Robert is an eight-year-old musically trained child. He had a great deal of trouble with the motor production, both with beat keeping and clapping back the non-pitch rhythms. He took as many as twelve tries before clapping one of the non-pitch rhythms (triple non-repeating motif).

Unlike Krista, however, Robert was good at the aural task. He missed only one congruent beat, and all of the beats which he identified as

congruent were, in fact, congruent. This indicates that his difficulty in drumming was not based on an inability to hear congruent beats.

Robert was also good at reading descriptions, both his own and those of others. He was equally good at the figural and metric forms of the duple repeated rhythm. He finally decided that his favorite was the M.3 description, although he had difficulty choosing between the F.2, M.2, and M.3 descriptions - a classic problem, since all three descriptions give considerable but different information about the rhythm.

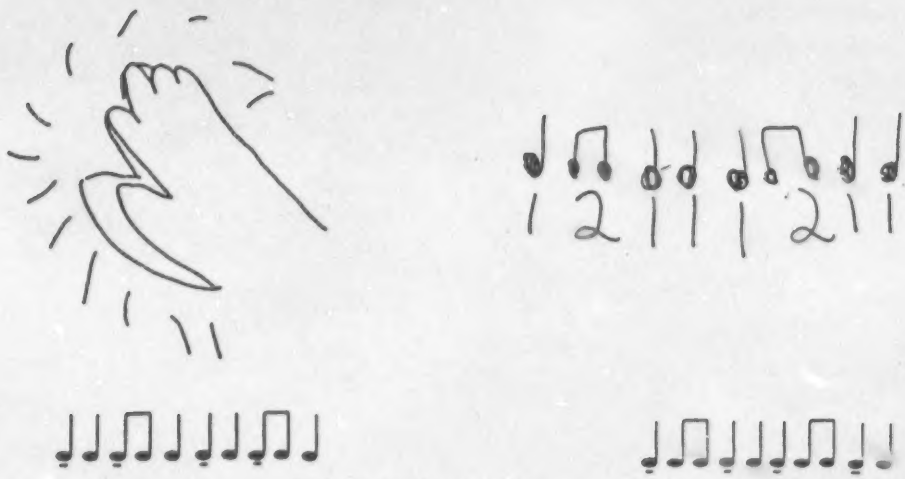
Robert clapped the duple non-repeating motif rhythm accurately the first time from an M.2 drawing. His favorite kind was M.3, and his overall metric score was higher than the figural score.

Robert's explanation of the drumming drawing was intuitive. This seems to be in line with his drumming ability. His drumming drawings, on the whole, were better than one might expect - he drew the duple hierarchy proportionally, and all other drawings but one were periodic.

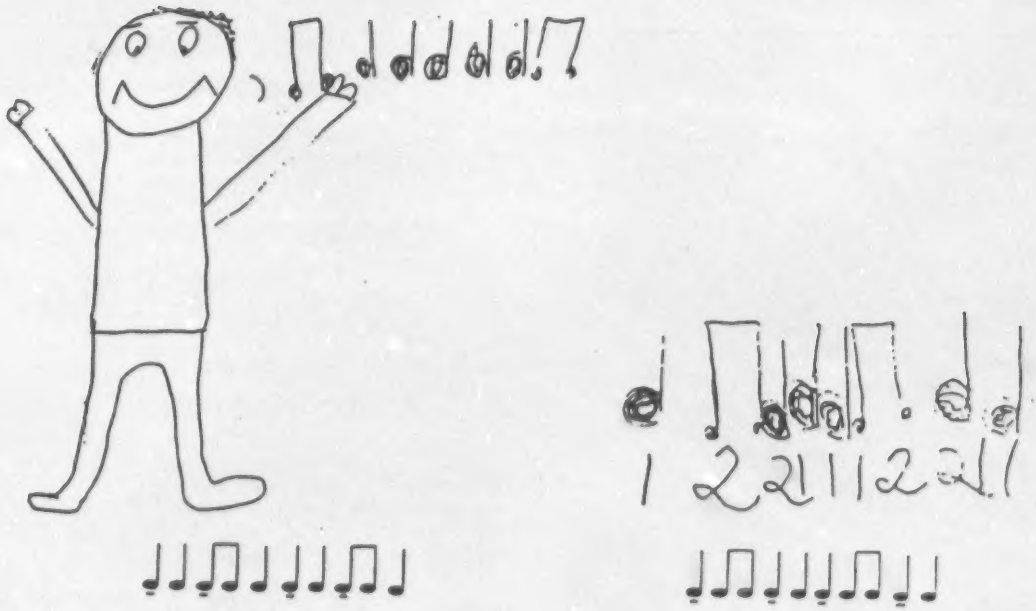
Change During the Course of the Interviews

Some of the statistically significant changes in notating the last duple repeated rhythm have been discussed, namely the significant drop in the number of errors and the increase in use of arbitrary symbols. Another striking change was the almost unbelievable leap made by two seven-year-old untrained boys from iconic representations of the first duple repeated rhythm to true metric representations for the last duple repeated rhythm (see Figure 19). Robin, an untrained seven-year-old, had considerable difficulty with the aural and motor tasks. Nevertheless he was able to accurately represent the last duple repeated rhythm usng standard music notation. Thomas also had trouble with the aural and motor tasks, but he was able to clap the simple rhythms accurately. Thomas was also more

Figure 19. Iconic and Metric Descriptions of the Duple Repeated Rhythms



7:2 untrained male
Thomas



7:8 untrained male
Robin

skilled at reading other descriptions of simple rhythms, although his explanation of the drumming description was intuitive.

Various reasons for the change can be postulated, all of which are tremendously important regarding teaching practices in general. For instance, one might ask if the children failed to understand the task when first faced with describing the simple rhythms. All too frequently, what are regarded as "errors" may simply be a reflection of a child's misunderstanding of what is expected. It is certainly possible that a child could interpret the instruction to "make some marks to remember the rhythm" as "draw a picture to remember that we clapped today", that is, to represent the activity of clapping rather than the rhythm itself. It is not clear from the protocols if Thomas's early iconic descriptions were due to lack of understanding of the task, or if the M.3 drawing was merely coincidentally correct, since he was not at all confident about the accuracy of his drawing. Also, since he had used notes in his icons before, he may have simply been drawing notes, which happened to coincide with the last duple repeated rhythm.

The change in Robin's form of description (bottom set of drawings), however, did not appear to result from a task clarification. During the description reading tasks Robin was fascinated by "what the other kids did". He studied the descriptions thoroughly, even though he was unable to clap a single description accurately the first time through. When the time came to desribe the last duple repeated rhythm, Robin made the graphic and numeric descriptions quickly, seemingly without effort or reflection. When asked "how did you make that drawing?", he replied that he had "used number 7 and number 1", referring to the M.2 and M.3 descriptions of the duple non-repeating rhythm he had been shown in the previous task. One cannot

help but be impressed by the potential power of even a short "intervention", and the obvious strength of example. By giving Robin the chance to compare various descriptions of a rhythm, he was able to transfer the repertoire of examples to the task of representing a new rhythm.

While an entire pedagogy cannot be based on a single protocol, there is serious cause for considering the value of exposing children to various views of the same phenomenon not only regarding musical rhythms but for other subject areas as well. By giving a child more than one window through which to peer, the child is not only more likely to make his own choice of viewpoint, but he is also likely to be more tolerant of other views - different from his own but equally valid.

Advanced Rhythm Understanding

It was expected that children with the most advanced understanding of rhythm would be able to relate, describe, and interpret both the figural and metric aspects of rhythmic organization.

Of the 72 children sampled, eight children appeared to exhibit this high degree of understanding. They were identified on the basis of the following criteria:

1. True metric drawing of the metric hierarchies generated by the duple and triple melodies (i.e., proportional levels which are congruent with the surface durations).
2. Perfect aural and motor scores.
3. Perfect reading scores for both the figural and metric descriptions for the duple repeated motif and duple non-repeating motif rhythms.
4. Proportional explanation of the drumming drawings.
5. Mixed graphic and numeric descriptions.

All of these children were musically trained. Most of the children (five of the six) were ten years of age or older, with the

exception of one eight-year-old girl. These children not only confidently exhibited understanding of both the figural and metric forms in the task measures, but also in their freely offered comments about the tasks themselves. This is one of the features which sets these children apart from the others, as well as the above-named criteria. Excerpts follow.

Describing Simple Rhythms

Sally (11T)

Sally (11 yrs.) was able to keep time with all of the melodies accurately, feeling the pulse for the beats she chose by emphasizing the metrical accents. She was also good at clapping the non-pitch rhythms.

Sally's reading of her own drawing was accurate, but her drawing contained an error in representing the actual rhythm. Upon hearing the actual rhythm, she corrected her drawing.

Sally was able to clap all of the F.2, M.2 and M.3 drawings for both the duple repeated motif rhythm and duple non-repeating motif rhythms accurately. She was surprised to find the relationship between the figural and metric drawings:

> S. (after clapping M.2 of the duple repeated motif rhythm) Oh wow! It's the same! Did I clap that the same as the other two (i.e., the two F.2 drawings)?... Oh man!

She chose an M.2 drawing as the best for the duple non-repeating motif rhythm, but an F.2 drawing for the duple repeated motif rhythm rhythm, commenting:

> S. (Re: F.2 drawing of duple repeated motif rhythm) It's sorta obvious to see the groups for that one.

Drawing the Metric Hierarchies with Spatial Analogs

Kyle (12T)

Kyle (12 yrs.) clapped accurately from his drawing, which was an

accurate representation of the rhythm. He was able to clap the figural and metric descriptions equally well, feeling the pulse in most cases. He chose F.2 drawings as his favorites for both the duple repeated motif rhythm and duple non-repeating motif rhythms.

Kyle thought hard about how to represent the drumming. He was aware that one of the melodies was in duple time, and the other in triple time. He was concerned with showing this in the representation, as well as depicting the proportionality:

> K. Drummer 1 can go like this [demonstrates]...how am I supposed to tell him that? This is hard.
> K. (Triple) Hey, that's a 3/4 beat, eh? I'd make sure they know this is 3/4 and this is normal, like 4/4. You can put a C [common time = 4/4], 'cuz it's just normal.

When asked to comment on the drumming drawings, Kyle noted the following:

> E. Can you explain how these drawings work?
> K. (Triple) Well, yeah, but say you were the first drummer, and that's all you had. You wouldn't know how fast to play it. Like you might go like this [drums a very fast beat], like continuous. You wouldn't really know ...like if you see it all together, you could see the pattern and know how to drum.
> K. (Triple) Well, it's the same thing. If you were the first drummer it looks just like the other one. You need the whole pattern or else 3/4 or something so you know how fast to play it and where to express the beat.

Kyle's drawings of the metric hierarchy with the spatial analogs were proportional in both cases, and lined up with the surface durations. Kyle also represented the metrical accents, and put a time signature with all of his drawings.

These results are exciting. Clearly children have strong skills and a firm understanding of many aspects of both the figural and metric rhythmic forms. The most important findings are summarized in the conclusions, along with implications for teaching and future research.

CONCLUSIONS

Perhaps the most singularly striking finding is that all children, regardless of age and prior musical experience, are able to make sense of both metric and figural descriptions of rhythm. Equally important is the finding that children vary considerably in their responses, despite similarity in age or training. This is in contrast to the research of Bamberger (1980, 1982) and Smith (1983), where much clearer divisions were found between musically trained and musically untrained children and adults. However, given the broad range of tasks that were presented in the present study and the lack of constraints on the form of the descriptions that the children were asked to produce, this is not a surprising result.

Even though there is considerable divergence in responses, there were some patterns of responses which may prove useful for predicting and describing a child's overall understanding of rhythm. By relating a child's motor, aural and symbolic abilities, one can begin to classify children according to their understanding across domains. For instance, it was shown that children who have poor motor skills tend also to have poor aural skills, and find the figural descriptions the most salient for decoding and encoding rhythm patterns. How can this knowledge be used?

One of the limitations of the present study is that, although we can now predict with greater accuracy children's abilities and preferences regarding rhythm, we are not able to describe how those responses can be changed, that is, how learning can be effected. If a child has poor aural and motor skill, does one begin by establishing firmer motor skills? Aural skills? Or teach metric notation? It has been shown that the power of example is substantial for relating figural and metric notation forms, particularly if one of the descriptions is of the child's own making. But

how much does the effectiveness of example depend on abilities in other domains?

While an intervention study needs to be carried out to address the specific teaching strategies for advancing rhythm understanding, there are several general implications which can already be derived from the present study. These are discussed in the following section.

Educational Implications

It has been stated that most traditional instruction emphasizes the metric aspects of rhythmic structure over the figural aspects. By stressing the metric or formal knowledge, teachers not only underplay the equally important figural aspect, but may also be speaking in terms that children cannot readily understand since the metric notation may not match their internal figural representations. This is even true of children with considerable musical training, who may encode rhythms figurally if their internal metric structures will not prove strong enough to encode a given rhythm figurally. Neglecting the possible mismatch between internal representations and descriptions of a phenomenon is a common failing, not only in music teaching, but in other subject areas as well. Bamberger (1982) notes that teachers often present subjects in formal terms, forgetting or ignoring the steps taken to reach the formal embodiment. Meanwhile, teachers nevertheless expect students to grasp the formal presentation without being exposed to the development process.

How can music teachers be more flexible, interweaving the figural and metric faces of rhythmic organization? If a teacher finds that a child encodes rhythms figurally but is also capable of responding to the metric structure by keeping time to music, metric notaion may be taught by relating the child's figural descriptions to his ability to keep time to

music, and in turn, relating these abilities to the metric description embodied in common music notation. In fact, Butler (1983) has developed a system consistent with this approach.

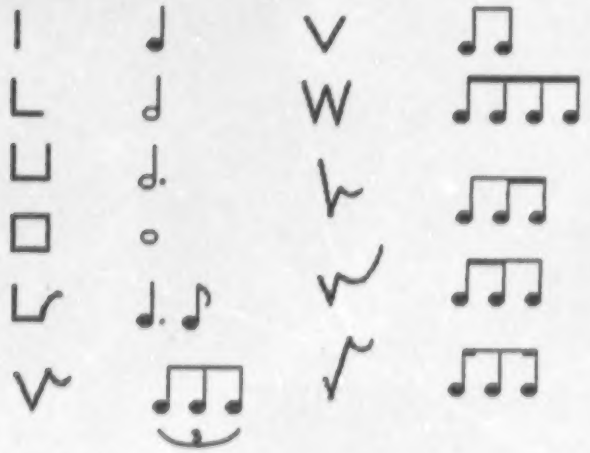
Butler (1983) uses an intermediate form of notation for teaching standard rhythm notation which includes both figural and metric aspects. This notational form, which Butler calls the "Kinesthetic Visual Transaction" form, is based on dividing and grouping the tactus of the rhythm to form figural descriptions of the varied durations. The tactus, regardless of the meter, is always represented by a single stroke. Divisions of the tactus in duple meter are represented by early figural descriptions. Grouping of the tactus is also by an early figural description, which can also be metrically related to the tactus. The notation is used for rhythm dictation, where the listener "kinesthetically" (like an early figural response) notates as he is listening to the piece. After the listener has notated the rhythm, it can be readily converted to the metric (visual) form, since the metric groupings are captured in the notation by using the tactus as a reference. Examples of this notation system are given in Figure 20, for both duple and triple meters.

Another potentially powerful transition notation is embodied in the form of description which was used to create a spatial analog of the melodies used in the metric hierarchy task. The use of vertical bars to indicate the time-span between notes, that is, using a spatial analogy to the time intervals, is capable of both figural and metric interpretation. Because the notation allows one to construct the coordinating metric hierarchy, the metric relationships between the various surface durations can be drawn. In fact, by simply joining some of the vertical bars together with a horizantal bar, and by adding a circle to the bottom of the

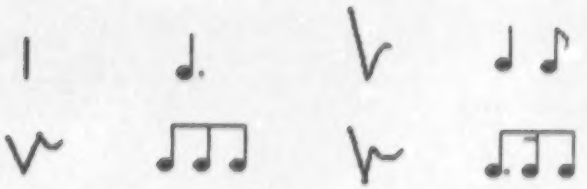
Figure 20. The Kinesthetic-Visual Transaction Notation

- vertical bar is the symbol for the tact, from which the other forms are based
- the symbols are contextual, e.g., the same symbol may stand for a quarter note in one context and a dotted quarter note in another

Simple Time

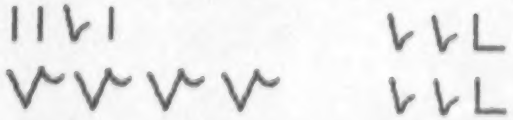


Compound Time

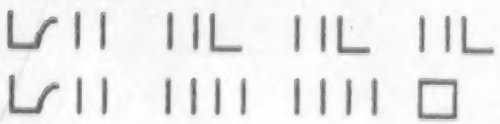


- the rhythm of the songs are notated as the song is sung or played

Row, Row, Row Your Boat



Mary Had a Little Lamb



vertical bars, one can readily translate the spatial analog to standard music notation (see Figure 21). In addition, the notation also has the makings of highlighting the figural groupings, since notes which appear together as spatial groups, are also often figural groups. This is because a change in duration, specifically, a relatively long duration after a series of short durations, often marks the the end of one figural group and the beginning of the next. Such a change of duration is evident in the spatial analog by a larger space between events. Thus, there is potential for using a spatial analog not only to relate children's figural knowledge to metric notation, but also to continue to show how the figural and metric modes interact in rhythmic organization.

The results and implications of the present research can also be viewed on a more general level, beyond the musical context. Research that emphasizes the value of multiple descriptions in the context of ecologically valid tasks has powerful implications for views on teaching and learning. Teaching is more likely to be effective if the teacher realizes that children have different (from adult descriptions and from those of other children) but equally useful descriptions at their disposal (Nelson, 1978). Teachers can use existing modes of description available to the learners to move to other forms of understanding. For example, by building on a child's figural understanding the teacher can move to a metric (or formal) embodiment of the phenomenon - in much the same way as the formal notation evolved historically (Apel, 1961; Houle, 1969; Vollaerts, 1960). One can also find a striking parallel in written language. The emergence and development of several qualitatively different forms of notation for language have been identified - hieroglyphic or syllabic, ideographic, and alphabetic (Nathan, Temple & Burris, 1982). All

Figure 21. The Conversion of the Spatial Analog to Music Notation

Full Music Notation

three are still in use today. However, as Temple et al. point out, because the English system is alphabetic adults may be 'blind' to the ideographic and syllabic forms, forms often used by children in their early writing. How like a music teacher who may also be 'blind' to the figural forms used by students, having been so firmly entrenched with metric notation. However, by showing students how both figural and metric forms historically evolved to sophisticated forms of rhythm description, teachers give credence to the view that both forms of rhythmic organization have a contribution to make to understanding rhythmic structure fully. In turn, this understanding can be related to making intelligent choices in performance, sometimes leading to a figural interpretation, sometimes strictly metric.

It is clear that the findings related in the present study are not limited to the understanding of rhythmic organization in music. Rather, there is a common thread running through the type of understanding and implications for teaching that have been described that encompass other areas of knowledge. Tolerance of different viewpoints from one's own, learning about how contrasting forms of description are related and evolve, and being able to change one's view of phenomena are fundamentally important for situations far beyond understanding the complexities of musical rhythm.

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Appendix A. Raw Data

OBS	AGE	TRNG	GRAPHICS	NUMBERS	ACCURACY	GROUPING	SYMBOL
				DR:TR:DN:TN:DL			
1	7	N	I: I: I: I: I	I:M1: I: I: I	N:N:N:N:N	N:N:N:N:N	A:A:A:A:A
2	7	N	I: I: I: I:M3	I: I: I: I:M2	N:N:N:N:Y	N:N:N:N:N	A:A:A:A:M
3	7	N	M1: I: I: I:F2	M1: I: I: I:M2	N:N:N:N:N	N:N:N:N:N	A:A:A:A:A
4	7	N	M1: I: I:M1:M1	M1: I:M1:M1:M1	N:N:N:N:Y	N:N:N:N:N	A:A:A:A:A
5	7	N	M1:M1:M1:M1:M1	M1:M1:M1:M1:M1	N:N:N:N:Y	N:N:N:N:N	A:A:A:A:A
6	7	N	I: I: I: I:M3	I: I: I: I:M2	N:N:N:N:N	N:N:N:N:N	M:M:A:A:M
7	7	Y	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:M
8	7	Y	F2:M1:M1:M1:M1	M3:M3:M3:M3:M3	N:Y:N:N:N	N:N:N:N:N	M:M:M:M:M
9	7	Y	F2:F2:F2:F2:F2	F: F:M3:M3:M3	Y:Y:Y:Y:Y	N:Y:Y:Y:Y	A:A:M:M:A
10	7	Y	F2:F2:F2:F2:F2	S: S: S: S: S	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
11	7	Y	I:M1:M1:M1:M1	M1:M1:M1:M1:M1	N:N:Y:N:Y	N:N:N:N:N	A:A:A:A:A
12	7	Y	I: I: I: I:M1	M3:M3:M3:M3:M1	N:N:N:N:Y	N:N:N:N:N	M:M:M:M:M

OBS	DRUM DESCR. DUPLE	DRUM DESCR. TRIPLE	HIERARCHY DESC. DUPLE	HIERARCHY DESC. TRIPLE	MOTOR SURFACE		THFIT DUPLE	ACTUAL TRIPLE	FAV DUPLE:TRIPLE
1	I	I	M1	I	1	Y	5:4	3:2	Y:Y
2	I	I	F	F	4	Y	5:1	3:0	N:N
3	M1	M1	F	F	4	Y	5:3	2:1	Y:Y
4	I	I	I	M1	4	N	2:2	2:2	Y:Y
5	I	I	M1	M1	2	Y	6:4	3:2	N:Y
6	I	I	I	I	3	Y	2:5	1:1	Y:N
7	M1	M1	M1	M1	2	Y	2:1	2:1	Y:Y
8	M2	M1	M1	M1	2	Y	3:2	3:1	Y:Y
9	M1	M1	M1	M1	2	Y	2:1	1:1	N:Y
10	M1	M1	M1	M1	3	N	5:5	2:2	Y:Y
11	M1	M1	M1	M1	2	Y	5:2	3:1	Y:Y
12	M1	M1	M2	M2	3	Y	4:3	2:2	Y:Y

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
1	0	1	3.0:2.0	3.0:2.7	F2:F2	M2	I
2	0	3	3.0:2.0	2.3:2.7	F2:F2	F2	M1
3	3	1	2.0:1.0	3.0:1.3	M3:F2	M2	M2
4	2	1	2.0:1.0	2.3:2.0	F2:M2	M2	M1
5	1	1	2.5:2.0	3.0:1.7	F2:F2	F2	M1
6	0	1	1.5:1.0	2.3:1.3	F2:F2	M2	I
7	1	0	1.5:1.0	1.7:1.0	F2:F2	F2	M1
8	1	1	2.5:2.0	2.3:1.0	M1:F2	M3	I
9	2	1	1.0:2.0	1.3:1.0	M2:F2	F2	M1
10	1	1	1.0:1.0	2.0:1.0	F2:M3	F1	M1
11	1	1	2.5:1.0	2.0:2.7	F2:M2	F2	M1
12	1	2	3.0:1.0	2.0:1.3	M1:F2	F1	M1

OBS	AGE	TRNG	GRAPHICS	NUMBERS DR:TR:DN:TN:DL	ACCURACY	GROUPING	SYMBOL
13	8	N	M2:M1:M1:M1:M3	F: F: S:M1:M2	Y:N:N:N:Y	N:N:N:N:N	M:M:M:M:A
14	8	N	M2:M2:F2:F2:M3	M2:M2: F: F:M2	Y:Y:Y:Y:Y	Y:Y:Y:Y:N	M:M:M:M:M
15	8	N	M2:F2:F2:F2:M3	F:M1:M1: F:M3	Y:Y:N:N:Y	Y:Y:Y:N:Y	M:M:M:M:M
16	8	N	M2:M1:M1:F2:F2	M2: F: F: F:M2	N:Y:N:N:Y	N:N:N:Y:N	M:M:M:M:A
17	8	N	F2:M2:F2:F2:M1	S: S: S: S: S	N:Y:Y:N:Y	Y:Y:Y:Y:Y	A:A:A:A:A
18	8	N	F2:F2:M1:M1:F2	F: F:M1:M1: F	Y:Y:Y:N:Y	Y:Y:Y:Y:Y	M:A:A:A:A
19	8	Y	F2/M3:F2:M1:F2:F2	F: F:M1: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:A:A:M:A
20	8	Y	F2:M1:M1:M1:M2	A: S: A: S: F	Y:Y:Y:N:N	Y:N:N:N:Y	M:A:A:A:A
21	8	Y	F2:F2:F2:F2:F2	S: S: F: S: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:A:A:A:A
22	8	Y	F2:F2:F2:F2:M3	A:M2: F: A: F	N:N:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:M
23	8	Y	F2:M3:F2:F2:M2	A:M3: A: A:M2	Y:Y:Y:N:Y	Y:N:N:Y:Y	M:M:M:M:A
24	8	Y	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:A:A:A:M

OBS	DRUM DESCR. DUPLE:TRIPLE		HIERARCHY DESC. DUPLE:TRIPLE		MOTOR SURFACE		THFIT DUPLE	ACTUAL DUPLE:TRIPLE	FAV
13	M1	M1	M1	M1	2	Y	3:2	2:1	Y:N
14	M1	M1	M1	M3	2	Y	3:3	3:2	Y:Y
15	M1	M1	M1	M1	3	Y	5:2	2:0	Y:N
16	M1	M1	M1	M1	4	Y	3:3	1:2	Y:Y
17	I	I	I	I	2	Y	3:3	3:2	Y:Y
18	M1	M1	F	F	4	Y	4:2	2:1	Y:Y
19	M2	M2	M3	M3	1	N	3:2	3:2	Y:Y
20	M1	M1	M1	M1	1	Y	2:2	2:1	Y:Y
21	M1	M1	M2	M3	2	Y	4:3	2:1	Y:Y
22	M2	M1	M1	F	3	Y	2:2	2:2	Y:Y
23	M1	M1	M2	M2	1	N	3:2	3:2	Y:Y
24	M1	M1	M1	M1	1	N	3:2	3:2	Y:Y

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
13	1	0	1.0:1.0	2.0:1.3	M3:M3	F2	M1
14	1	0	1.0:1.0	1.0:1.0	M2:M3/M2	M3	M1
15	1	0	1.0:1.0	1.3:1.3	F2:M2	M3	M1
16	2	1	2.5:1.5	2.7:2.0	F2:F1	M2	M1
17	1	0	2.5:1.0	1.3:1.7	F2:M3/M2	M3	M1
18	2	1	2.5:1.5	2.0:1.0	F2:M3	F2	M1
19	1	0	1.0:1.0	1.0:1.0	F2:F2	M3	M2
20	1	0	2.0:1.0	2.3:1.7	F2:F2	M2	M2
21	1	0	3.0:1.0	1.3:1.0	F2:M2	M2	M2
22	1	5	1.0:1.0	1.0:1.7	M3:M3	M2	I
23	1	0	1.0:1.0	1.3:2.7	F2:M2	M2	M2
24	1	0	1.0:2.0	1.0:1.7	M3:M3/M2	M3	M1

OBS	AGE	TRNG	GRAPHICS	NUMBERS	ACCURACY	GROUPING	SYMBOL
				DR:TR:DN:TN:DL			
25	9	N	M2:F2:F2:F2:M2	M2:M2:M2:M2:M2	Y:N:N:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
26	9	N	M2:F2:F2:F2:F2	M2:M2:M2:M2:M2	Y:Y:Y:N:Y	Y:Y:Y:Y:Y	A:A:A:A:A
27	9	N	M2:F2:F2:F2:F2	M1: F:M1:M1: S	Y:N:N:N:N	N:Y:Y:Y:N	A:A:A:A:A
28	9	N	M2:M1:F2:F2:M3	M1: F:M3:M3:M3	Y:N:N:N:Y	Y:N:N:N:N	A:M:M:M:A
29	9	N	F2:M1:M1:F2:M1	S: S: S: S: S	Y:N:Y:N:N	N:N:N:N:N	A:A:A:A:A
30	9	N	M3:F2:F2:F2:M3	M3:M2:M2:M2:M2	N:Y:N:N:Y	N:Y:Y:N:N	M:M:M:M:M
31	9	Y	M3:F2:M3:M3:M2	M3:M2:M2:M2:M2	N:Y:N:N:Y	N:N:N:N:N	M:M:M:M:A
32	9	Y	M3:M1:M1:M1:M3	M3:M1:M1:M1:M3	Y:N:N:N:Y	N:N:N:N:Y	M:M:M:M:M
33	9	Y	F2:F2:F2:F2:M2	F: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:A
34	9	Y	M2:M1:M2:F2:M2	M2:M2:M2: F:M1	N:N:N:Y:Y	N:N:N:Y:N	A:A:A:A:A
35	9	Y	M2:M1:F2:M2:F2	M2:M2:M2:M2:M2	Y:Y:N:Y:Y	N:N:N:N:Y	A:A:A:A:A
36	9	Y	F2:F2:F2:F2:M3	F: F: F: F:M3	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:M

OBS	DRUM DESCR. DUPLE:TRIPLE		HIERARCHY DESC. DUPLE:TRIPLE		MOTOR SURFACE		THFIT DUPLE:TRIPLE	ACTUAL DUPLE:TRIPLE	FAV
25	M1	M1	F	M1	3	Y	5:4	3:2	Y:Y
26	M1	M1	M1	M1	3	Y	3:2	1:1	N:Y
27	M1	M1	M1	M1	2	Y	5:3	3:1	Y:Y
28	M1	M1	M1	M1	2	N	3:3	3:2	Y:Y
29	M1	M1	M1	M1	2	Y	3:2	2:2	Y:Y
30	M1	M1	F	F	2	Y	4:1	2:1	Y:Y
31	M1	M1	M1	M1	2	Y	3:1	3:1	Y:Y
32	M1	M1	M1	M1	1	N	3:3	3:2	Y:Y
33	M1	M1	F	F	1	N	2:2	2:2	Y:Y
34	M1	M1	M1	M1	2	Y	5:2	3:1	Y:Y
35	M1	M1	M1	M1	1	N	2:2	2:1	Y:Y
36	M1	M1	M2	M1	1	N	3:2	3:2	Y:Y

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
25	1	O	1.0:1.0	1.0:2.3	M3:M3/M2	M3	M1
26	1	O	1.0:1.0	1.3:1.3	F2:F2	M3	M1
27	1	O	1.0:1.5	2.3:1.0	F2:M2	M2	M2
28	2	1	2.0:1.0	1.7:1.7	F2:M3	F2	M1
29	2	1	2.5:1.5	2.0:1.7	M3:M3	M3	M1
30	2	2	2.0:2.0	2.0:1.7	M2:M3	M3	M1
31	2	2	2.0:1.5	2.7:2.3	F2:M3	M3	I
32	2	1	3.0:1.0	1.3:2.0	F2:M2	M2	M1
33	1	O	1.5:1.0	1.0:1.3	F2:M3	M3	M1
34	1	1	1.0:1.0	1.3:1.7	M2:M3	M3	M1
35	3	1	1.0:1.0	2.3:2.0	F2:M3	M3	M1
36	1	O	1.0:1.0	1.0:1.3	F2:M2	M2	M2

OBS	AGE	TRNG	GRAPHICS	NUMBERS DR:TR:DN:TN:DL	ACCURACY	GROUPING	SYMBOL
37	10	N	F2:F2:F2:F2:F2	F: S: S: F: S	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
38	10	N	F2:F2:F2:F2:F2	F: S: S: S: S	Y:Y:Y:N:Y	N:Y:Y:Y:Y	A:M:M:A:A
39	10	N	M3:M1:F2:F2:M3	M2:M2:M2:M2:M2	N:N:N:N:Y	N:Y:Y:Y:N	M:M:M:M:M
40	10	N	F2:M2:F2:F2:M3	A: A: A: A:M2	Y:Y:Y:N:Y	N:Y:Y:N:Y	A:A:A:A:A
41	10	N	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:N	A:A:A:M:A
42	10	N	M3:F2:F2:F2:F2	M2: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:A:A:A:A
43	10	Y	M3:F2:F2:F2:F2	M3:M3:M3:M3:M2	Y:N:N:N:Y	N:Y:Y:Y:Y	M:M:M:M:A
44	10	Y	M3:M3:F2:M3:M3	M2: F: F: F:M2	Y:Y:Y:Y:Y	N:Y:Y:Y:Y	M:M:M:M:M
45	10	Y	M2:F2:F2:F2:F2	S:M1: S: S:M2	Y:Y:Y:Y:Y	Y:Y:Y:Y:N	A:A:A:A:A
46	10	Y	F1:F2:F2:F2:F2	M1: S: S:M1:M2	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
47	10	Y	M3:M1:F2:F2:F2	M2:M2: F:M2: F	N:Y:Y:N:Y	N:N:Y:Y:Y	M:A:M:M:A
48	10	Y	M2:F2:F2:F2:M2	S:M2:M2: F:M2	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A

OBS	DRUM DESCR. DUPLE	DRUM DESCR. TRIPLE	HIERARCHY DESC. DUPLE	HIERARCHY DESC. TRIPLE	MOTOR SURFACE	THFIT	ACTUAL DUPLE	ACTUAL TRIPLE	FAV
37	F	F	F	F	5	Y	3:2	2:1	N:Y
38	M1	M1	M1	M2	1	N	3:2	3:2	Y:Y
39	M1	M1	M1	M1	1	N	3:3	3:2	Y:Y
40	M2	M1	M1	M3	2	Y	4:1	2:1	Y:Y
41	M1	M1	M1	F	3	Y	2:2	2:2	Y:Y
42	M1	M1	M1	M1	1	Y	1:1	1:1	Y:Y
43	M1	M1	F	F	1	Y	3:2	3:2	Y:Y
44	M1	M1	M3	M3	1	N	3:2	3:2	Y:Y
45	M1	M1	M2	M2	2	Y	3:2	3:1	Y:Y
46	M1	M1	M1	M1	1	N	3:2	3:2	Y:Y
47	M1	M1	F	F	2	N	3:4	1:1	N:N
48	M2	M1	M3	M3	1	N	3:2	3:2	Y:Y

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
37	2	1	2.0:1.5	2.3:1.7	F1:F1	F1	M1
38	2	1	1.0:1.0	1.3:1.3	M2:M3	M3	M2
39	1	1	1.0:1.0	1.3:2.0	M2:M3	M3	M2
40	1	0	2.0:1.0	2.0:1.3	F2:M2	M3	M1
41	1	0	2.0:1.0	2.0:1.3	F2:F2	F1	M2
42	1	0	2.0:1.0	1.7:1.3	F2:M3	M3	M1
43	1	0	1.5:2.0	1.0:1.7	M2:M3	M3	M1
44	1	0	1.0:1.0	1.0:1.0	M3:M3	M3	M2
45	1	0	1.5:1.5	1.3:1.0	F2:M2	M2	M1
46	1	0	1.0:1.0	1.3:1.0	F2:M3	M3	M1
47	1	6	2.0:1.5	1.7:1.3	F2:F2	F2	M1
48	1	0	1.0:1.0	1.0:1.0	F2/M3:M3	M3	M2

OBS	AGE	TRNG	GRAPHICS	NUMBERS DR:TR:ON:TN:DL	ACCURACY	GROUPING	SYMBOL
49	11	N	F2:F2:M1:M1:F2	F: F:M1: F: F	Y:Y:N:Y:Y	N:Y:N:N:Y	A:A:A:A:A
50	11	N	F2:M2:F2:M1:F2	F:M2: S: S: S	Y:Y:Y:Y:Y	Y:Y:Y:N:Y	M:A:A:A:A
51	11	N	F2:F2:F2:F2:F2	F: F: S: S:M3	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
52	11	N	F2:F2:F2:F2:M1	F: F: F: F: F	Y:Y:Y:N:Y	N:Y:Y:Y:N	M:M:A:A:A
53	11	N	M2:F2:F2:M2:M2	M2:M2: F:M2:M2	Y:Y:Y:Y:Y	N:Y:Y:Y:N	A:A:A:A:A
54	11	N	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:N:Y:Y	N:Y:Y:Y:Y	A:A:A:A:A
55	11	Y	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:A
56	11	Y	F2:F2:F2:M1:F2	S: F: S: S: F	Y:Y:Y:Y:Y	Y:Y:Y:N:Y	M:A:A:M:A
57	11	Y	F2:F2:F2:F2:F2	M1:M1: S: F: F	Y:N:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:M
58	11	Y	F2:F2:F2:F2:M2	F: F: F: F:M2	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:M
59	11	Y	F2:M3:M3:F2:F2	F:M2:M3:M3: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:A
60	11	Y	M3:F2:F2:F2:M3	F: F:M1:M1:M1	N:Y:Y:Y:Y	N:Y:Y:Y:Y	M:M:M:M:M

OBS	DRUM DESCR. DUPLE	DRUM DESCR. TRIPLE	HIERARCHY DESC. DUPLE	HIERARCHY DESC. TRIPLE	MOTOR SURFACE		THFIT	ACTUAL DUPLE:TRIPLE	FAV
49	M1	M1	M2	M2	2	N	1:2	O:1	N:N
50	M1	M1	M1	M1	2	N	5:3	3:O	N:N
51	M1	M1	M1	F	1	N	3:2	3:2	Y:Y
52	M1	M1	M2	M1	1	Y	4:2	3:2	Y:Y
53	M1	M1	M2	M2	2	N	3:2	3:2	Y:Y
54	M1	M1	M2	M1	3	Y	4:2	3:1	Y:Y
55	M2	M2	M3	M3	1	N	3:2	3:2	Y:Y
56	M1	M2	M3	M3	1	N	3:2	3:2	Y:Y
57	M1	M1	M1	M1	3	Y	3:2	3:2	Y:Y
58	M1	M1	M1	M1	1	N	3:2	3:2	Y:Y
59	M1	M1	M3	M1	1	N	3:2	3:2	Y:Y
60	M2	M2	M3	M3	1	N	3:2	3:2	Y:Y

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
49	1	O	1.O:1.O	1.O:1.O	F2:M3	M3	M2
50	1	O	1.O:1.O	1.7:1.3	F2:F2	M2	M1
51	1	1	1.O:1.O	1.O:1.O	F2:M2	M3	M2
52	1	O	1.O:1.O	1.3:1.O	F2:F2	F2	M1
53	1	O	1.5:1.O	1.O:1.O	F2:M2	M2	M2
54	1	O	1.O:1.O	1.7:1.3	F2:F2	M3	M2
55	1	O	1.O:1.O	1.O:1.O	F2:F2	M2	M2
56	1	O	1.O:1.O	1.3:1.3	F2:F2	M2	M2
57	1	1	1.O:1.O	1.3:1.O	F2:F2	F2	M1
58	1	O	1.O:1.O	1.O:1.O	F2:M2	M2	M1
59	1	O	1.O:1.O	1.O:1.O	F2/M3:M2	M2	M2
60	1	1	1.O:1.O	1.O:1.O	F2:M2	M2	M2

OBS	AGE	TRNG	GRAPHICS	NUMBERS DR:TR:DN:TN:DL	ACCURACY	GROUPING	SYMBOL
61	12	N	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:N:Y	Y:Y:Y:Y:Y	A:A:A:A:A
62	12	N	F2:F2:F2:F2:F2	M1: F:M1:M1: F	Y:Y:Y:N:Y	Y:Y:Y:Y:Y	A:A:A:A:A
63	12	N	F2:F2:F2:F2:F2	F:M1:M1:M1: F	Y:Y:Y:Y:N	Y:Y:Y:Y:Y	A:A:A:A:A
64	12	N	F2:F2:F2:F2:F2	F: F: F: F: F	Y:N:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
65	12	N	F2:F2:F2:F2:F2	F:M2:M1:M1: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
66	12	N	F2:F2:M3:F2:F2	F: F:M2: F: F	Y:Y:Y:Y:Y	Y:Y:N:Y:Y	A:A:A:A:A
67	12	Y	F2:F2:F2:F2:M2	F: F: F: F:M3	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
68	12	Y	F2:F2:M2:F2:M2	A: F:M2: F: F	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	A:A:A:A:A
69	12	Y	M3:F2:M3:F2:M3	M2:M2:M2:M2:M3	Y:Y:Y:Y:Y	Y:Y:Y:Y:Y	M:M:M:M:A
70	12	Y	F2:F2:M2:F2:F2	F: F: F:M1: F	Y:Y:N:Y:Y	N:Y:Y:Y:Y	A:A:A:A:A
71	12	Y	F2:F2:F2:F2:F2	F: F: F: F: F	Y:Y:Y:N:Y	Y:Y:N:Y:Y	A:A:A:A:A
72	12	Y	F2:M1:M1:M1:F2	F:M2: S:M1: F	Y:Y:N:N:Y	Y:Y:N:N:Y	M:M:M:A:A

OBS	DRUM DESCR. DUPLE:TRIPLE		HIERARCHY DESC. DUPLE:TRIPLE		MOTOR SURFACE		THFIT DUPLE:TRIPLE	ACTUAL	FAV
61	M1	M1	M1	M2	2	Y	3:2	3:2	Y:Y
62	M1	M1	M1	M1	1	Y	3:3	3:2	Y:Y
63	M2	M2	M1	M2	2	Y	3:3	3:2	Y:Y
64	M2	M2	M1	M1	1	Y	3:2	3:2	Y:Y
65	M2	M1	M1	M1	1	N	4:2	3:2	Y:Y
66	M1	M1	M1	M1	2	Y	4:3	3:2	Y:Y
67	M2	M2	M3	M3	2	Y	3:2	3:2	Y:Y
68	M1	M1	M1	M1	1	N	4:2	3:2	Y:Y
69	M2	M2	F	F	1	N	3:2	3:2	Y:Y
70	M1	M1	M1	M1	1	Y	3:2	3:2	Y:Y
71	M2	M2	M1	M1	1	N	4:2	3:2	Y:Y
72	M1	M1	M1	M1	2	Y	2:2	1:0	Y:N

OBS	READ/OWN	CLAP	READ/DR MET:FIG	READ/DN MET:FIG	FAV DR:DN	FIRST/DN	DRUM EXP.
61	1	0	2.0:2.0	1.3:1.3	M3:F2	M3	M1
62	3	1	2.0:1.0	2.3:1.0	F2:F2	F2	M1
63	2	1	2.0:1.0	2.0:1.3	F2:F2	F2	M2
64	1	1	2.5:1.0	1.3:1.3	F2:M2	F2	M1
65	1	0	2.0:1.0	2.0:1.0	F2:F2	F2	M2
66	1	0	2.5:1.0	1.7:1.3	F2:F2	M3	M2
67	1	0	1.0:1.0	1.0:1.0	F2:F2	F2	M2
68	1	0	1.0:1.0	1.0:1.0	M3:M2	F2	M2
69	1	0	1.0:1.0	1.0:1.3	M3:M3/M2	M3	M1
70	1	0	1.5:1.0	1.0:1.0	F2:M2	M2	M1
71	1	0	1.5:1.0	1.0:1.0	F2:M2	M2	M2
72	1	1	1.0:1.0	1.7:1.3	F2:F2	M3	M1